Carbonization Conference.

Birmingham, Feb. 21 to 24, 1928.

REPORT OF THE DISCUSSIONS.

[These pages form a Supplement to the Special Number of the "GAS JOURNAL" published on Feb. 14.]

SESSION I.—Dr. G. C. CLAYTON, M.P. (Society of Chemical Industry), in the Chair.

Dr. CLAYTON, before calling on the authors of the papers, said the Conference was the fourth of a series which had been organized by the Joint Fuel Committee formed some three or four years ago by the Society of Chemical Industry, the Institution of Gas Engineers, and the Coke Oven Managers' Association. The Institute of Fuel also was now operating with the Joint Fuel Committee; this being the first conference in which it had participated. The importance of research into fuel did not require emphasizing; but the equal, or even greater, importance of applying the great mass of information which existed on fuel utilization, did not always attain such prominence. The object of the Joint Fuel Committee was to spread accurate information by means of conferences and discussions. The importance of this object had always been stressed by the Fuel Research Board, of which he was a member; and in its earliest days Sir George Beilby had pointed out that "in any practical programme for fuel economy, the first place ought to be assigned to the putting in order, without loss of time by the consumers themselves, of a system of control which will ensure that a stop shall be put to gross waste, and that the existing appliances and known methods are worked to the best advantage." The subject of the proceedings that day, continued Dr. Clayton, referred to the problems of the gas industry, and was very comprehensive. Two at least of the papers had been given before, but were again brought forward to afford a further opportunity for discussion. The gas industry had always been in a somewhat unique position in that the freest interchange of views took place between the various authorities and technical workers; and it was probably largely owing to this that the gas industry had developed along sound, if somewhat cautious, lines to its present magnitude. Inasmuch as there was little direct competition between the different companies, the gas industry was perhaps in a somewhat favoured position; but there was no doubt that progress would be stimulated similarly by freer interchange of data and experience in other industries. Gratifying progress had already taken place in this direction—the formation of co-operative research associations emphasized this fact—but much more remained to be done. In certain other sections of the fuel industries there was still a certain amount of hesitation by firms in putting the whole of their cards on the table. This fear, however, was gradually being broken down, and there could be no doubt that the conferences organized by the Joint Fuel Committee would provide a stimulus in that direction. All who were interested in research were aware of the period which invariably followed the completion of research before it was taken up by industry; and it was hoped that such conferences as this, at which were present representatives of the various industries, would help to curtail that waiting period.

The following papers were then presented and discussed together. [The full text of the contributions to the conference was published on Feb. 14 in a special number of the "GAS JOURNAL."]

(*a*) "THE GAS INDUSTRY: PAST, PRESENT, AND FUTURE." Inaugural Address of the Chairman of the London Section of the Society of Chemical Industry. By W. J. A. Butterfield, M.A., F.I.C., on Oct. 3, 1927.

(*b*) "SOME PHASES OF MODERN PRACTICE IN GAS MANUFACTURE." By Thomas Hardie, M.Inst.C.E.

(*c*) "PRESIDENTIAL ADDRESS TO THE SOUTHERN ASSOCIATION OF GAS ENGINEERS AND MANAGERS, 1927." By Thomas Hardie, M.Inst.C.E.

(*d*) "CONTINUOUS VERTICAL RETORTS." By Michael Barash, M.Sc.(Tech.), A.I.C., and T. Campbell Finlayson, M.Sc., A.M.I.Chem.E.

(*e*) "VERTICAL INTERMITTENT CHAMBER OVENS FOR GAS MANUFACTURE." By N. J. Bowater, O.B.E., B.Sc., Assoc.M.Inst.C.E.

(*f*) "INTERMITTENT VERTICAL CHAMBERS." By R. H. Ruthven.

DISCUSSION.

COKE OVENS FOR GAS-WORKS—PROS AND CONS.

Mr. G. J. GREENFIELD, referring to Mr. Hardie's papers, asked, in view of the great development of the use of coke ovens for gas making, what factors influenced Mr. Hardie against their use as compared with other forms of carbonizing plant. Being a coke oven man, he regarded coke ovens as the most economical plant, and he felt it would be enlightening to himself and to his coke oven brethren if they were told what were the limitations of their process which made it less desirable for gas making than the other processes. One point in its favour was that it occupied less ground-space than others. A short time ago he had had a visit from one who was connected with a large gas-works, who had remarked that the space occupied by his (Mr. Greenfield's) carbonizing plant was about equal to that occupied by one retort house, and that it would need four retort houses to equal its throughput.

Mr. E. G. STEWART (Gas Light and Coke Company), replying on behalf of Mr. Hardie, said that so far as he was aware there were a number of points wherein coke ovens did not come up to the present plant. First of all, with coke ovens there was a reduction in therm yield, which was a very serious matter. One could take it, for example, that horizontal retorts would yield 72 therms per ton, but he was yet unaware of a coke oven which could claim that yield from a similar coal. The reduction in labour and maintenance costs with coke ovens did not by any means balance the big loss of 4 or 5 therms per ton. Secondly, there was the point, which he believed coke oven people were prepared to admit, that a coke oven installation did not really begin to get economical until it reached a capacity of the order of 900 or 1000 tons per day. The third point related to the coke produced. He was not yet convinced that oven coke was as good for the domestic consumer, burning coke in the appliances he used at the present time, as horizontal retort or, more particularly, vertical retort coke. Those, he believed, were broadly the points Mr. Hardie had had in mind when he had said that at the moment coke ovens had not shown the same advantages as did the existing plants at the Gas Light and Coke Company's works. At the same time, he (Mr. Stewart) did not think many years would elapse before the Company had a coke oven installation, in order to try out these matters in practice.

Mr. SENSICLE said Mr. Greenfield had rather taken the wind out of his sails, because he also had intended to ask what were the factors which had influenced Mr. Hardie against the adoption of coke ovens. The Gas Light and Coke Company had the largest output in the world, and their works seemed to be a very suitable place for trying out a coking plant. Coking plants were admittedly more economical when on a big scale. Mr. Sensicle gave figures relating to a plant which was making about 20 million c.ft. of gas per day, which showed that from the point of view of saving ground-space the coke oven plant was particularly favourable. Mr. Hardie had given figures relating to inclined, horizontal, and continuous vertical retorts, and it would be interesting to compare them with the figures relating to coke ovens. Mr. Hardie had shown that 212 c.ft. of gas was made per 24 hours per sq. ft. of site with inclined retorts, 267 c.ft. with horizontal retorts, and 531 c.ft. with the continuous verticals. The speaker had calculated that the output of a coke oven plant such as he had mentioned would be 1000 c.ft. per day per sq. ft. of site. The corresponding figures in therms were 1·15, 1·48, 2·71, and 5·00 respectively. The figures of thermal consumption for carbonization were also in favour of coke ovens. A regenerative coking plant consumed from 800 to 900 B.Th.U. per lb. of coal carbonized. Working

from Mr. Hardie's figures—which were presumed to represent fairly modern practice—and allowing for waste heat credits, the figure for horizontal retorts was 1470, and for continuous verticals 1371 B.Th.U. There was a great advantage in that respect, therefore, in the use of coke ovens. With regard to the coke obtained from coke ovens, he believed it would be admitted that in the very latest type of coke oven—about 14 in. wide—it was possible to make a coke which was equally as reactive and as suitable for household uses as that made by any other plant. The carbonizing time corresponded closely with that of a horizontal retort, and the rate of heat penetration was very similar. Therefore, the properties of the coke should be similar as regards combustibility and reactivity, though, as yet, not understood very thoroughly.

The Question of Ground-Space.

Dr. E. W. Smith, dealing with Mr. Sensicle's reference to the small amount of ground-space required for coke ovens, said it would be useful if he would say whether his calculations included producer gas firing, and whether he had included the ground-space occupied by the external producers; if not, it would be interesting to know whether the output of gas of a self-contained gas-fired coke oven was taken as the total, or the 60 p.ct. or so which was available for town's supply, and whether the ground-space occupied included the whole of the track necessary for the charging machine and the pushers. His own information did not correspond with that given by Mr. Sensicle. With regard to the fuel, Dr. Smith asked whether Mr. Sensicle, in arriving at his figures for other systems than coke ovens, had given full credit for the waste-heat recovery. It was well known that waste-heat recovery was possible to a much greater extent in other systems than in coke ovens, because of regeneration. He wanted to ensure that if any figures were put forward they were really on an understandable and comparative basis, as accepted by gas engineers to-day.

Mr. Sensicle said Mr. Hardie's paper stated the amount of waste-heat recovery possible, and he had taken that into consideration in his calculations when comparing the heat required for carbonization in the various systems. With regard to the space required for the coke oven plant, he had allowed for the ram track, for the coke car track, for the coal storage bunker, and for a cooling tower. He had not allowed for the external producers, which he did not think should take up very much more room; they might possibly be put under the bunker. With regard to thermal yield, he had allowed for the whole of the gas from the oven to be recovered, and external producers would be used for heating. He had allowed for a 40 ft. oven, a 40 ft. ram bench, and a length of about 150 ft. for the battery.

Mr. John Roberts pointed out the figure given by Mr. Sensicle as representing the heat required for carbonizing coal in coke ovens did not agree with that given by Messrs. Greenfield and Harrison, in their paper on "Modern Coke Oven Practice," which was to be read at the conference. Their figure was 1000 to 1100 B.Th.U., but they were hoping to reduce it to 900 B.Th.U.

Mr. T. Campbell Finlayson remarked that in continuous verticals the heat consumption per lb., allowing for the recovery of waste heat, was approximately 914 B.Th.U. Mr. Sensicle had probably taken the figure of 596,000 B.Th.U. in Mr. Hardie's paper (Table 2), which figure related to steam. That, of course, was the surplus after providing all the power for the works, and, therefore, it did not come into the straightforward thermal consideration.

Mr. Arthur H. Lymn urged that when speaking of gas producers in connection with coke oven plant it was necessary to look upon the matter in a rather more rational way. Mr. Sensicle had suggested that the producers might be put under the coal bunker; but if one were going to fire a big plant such as is now being installed in the North—of a capacity of 10,000 tons per week, for example, one needed 10 or 12 producers, probably of the mechanical type, with all the necessary accessories for cleaning the gas, and so on. That was not the type of plant that could be put under a coal bunker. It would certainly occupy a very substantial area, and he agreed with Dr. Smith that this should be taken into full consideration in giving comparative figures.

Mr. E. G. Stewart pointed out that a large number of the Gas Light and Coke Company's works were situated in town areas, and the problems of smoke production in charging, and steam in discharging, had to be taken into serious consideration. That was another factor which had influenced their choice of plant. They had really only two works at which large installations of coke ovens were possible on that score.

Mr. Greenfield, commenting on Mr. Sensicle's remarks, said he had yet to see a coke-oven plant, only 50 yards long, capable of producing 20 million c.ft. per day.

Each Works a Separate Problem.

Dr. Smith, in order to stimulate discussion, said he knew there were many present who had a great deal to say, but possibly they thought that what they had to say was a matter of detail; detail was wanted, however. In the first place, he would like to put to gas engineers the query as to whether the time had not come for them, instead of following one another very largely in the fashion of carbonizing plants, rather to accept the proposition that every gas-works required its own special consideration, and that what was good for one works was not necessarily good for another works even just across the way; that there were different systems of carbonizing, each of which had its own peculiar set of conditons and its own peculiar requirements. Although he was particularly interested in two or three different systems, he recognized that coke ovens had their place, and an increasing place, in very large works. Possibly, in view of the geographical position of the Beckton Works, and inasmuch as the Great War was quite recent, the Gas Light and Coke Company would have to think twice about installing such plant there; it would have been impossible to run coke ovens, and to produce the great flares which those ovens produced, at the mouth of the Thames during the war. There were coke ovens at Saltley during the war, but they had to be closed down during air raids. That was a matter of minor importance to Birmingham, which was very far away; but at the mouth of the Thames it would have been impracticable, and would be impracticable in the future, if there were a likelihood of war and of extensive air raids, to use such plant, because the bigger the production of coke oven gas, the more serious it would be from the point of view of the supply of gas in the City of London if the coke oven plant were closed down. The type of carbonizing plant which gave the least amount of smoke and the least amount of glare and flare, situated preferably in a retort house, was the type to which, in London particularly, consideration would have to be given.

The Guarantee Bogey.

There was one point in which he personally was very much interested, and in connection with which he was afraid he had not much sympathy in any quarter—namely, that he believed a great deal of harm was done to-day by gas engineers stipulating rigid, excessive guarantees of a fictitious nature with regard to tests carried out over short periods. He put it to them that it was infinitely better to take the overall costs of gas production, whatever the system, in preference to some spectacular figure of thermal yield per sq. ft. of ground space, or thermal yield per ton of coal. There were many installations—some of which he knew intimately, and many of which he knew of only by hearsay—which had been spoiled because of the unbusinesslike insistence of gas engineers upon obtaining figures which, though they could be obtained readily, could only be obtained at the expense of straining the refractories, the buckstays, and the whole setting. In that way one could get figures which might appear very good for presentation to a Gas Committee or a Board of Directors, or might appear very attractive in (say) a technical paper which might subsequently be written; but, from the point of view of gas production and of gas costs over a period of 10 or 20 years—and that was what really mattered—they were valueless. Real harm had been done to many installations—not just one or two, but many—by guarantees being put up to one contractor and then transferred to another, so that each was working against the other in order that they might be increased and increased, until an impossible figure had been demanded and obtained over a short period, much to the detriment of the plant. Dr. Smith suggested that the basis of these strict guarantees was a matter which might be discussed with advantage. Let them be strict; but let them be guarantees which were going to be conducive to the production of cheap gas, and not guarantees which would give one the satisfaction of doing a contractor down or of finding that he had stretched them—there was no satisfaction in that.

"Puffs" and Inadequate Information.

Another point he emphasized was that when figures were discussed, all the relevant information in connection with the tests or runs should be submitted to technical men. It was all very well to put inadequate information forward, for Stock Exchange purposes [Laughter]; but if discussions by technical men were to be of any value, it was necessary to have all the relevant information. He had in mind a series of tests, with which he had been associated, and which had been going on for perhaps two years, in connection with the intermittent vertical retorts at Ramsgate. It was easy, with intermittent vertical retorts, to obtain a very high thermal yield per ton of coal, and that yield, stated alone, was attractive; but in getting the high thermal yield per ton, the amount of the coal carbonized per day was considerably reduced. Consequently, the advantage of the high thermal yield per ton was largely nullified by the reduced output of therms per day. Ten-hour charges at a moderate thermal yield per ton were better financially than 12-hour charges with 2 hours' steaming, at a higher thermal yield per ton, and better still than 15 or 18 hour charges with a very much increased thermal yield per ton. The factor that mattered most was the mean figure of the highest thermal yield per day, taken in conjunction with the price of coal and the coal from which the therms had been obtained; and it could readily be shown that attractive figures in thermal yield per ton were of but secondary importance—an excessive yield of, say, 87 therms per ton from Londonderry coal, which was readily obtainable. Another way in which gas engineers could render a great deal of help was by discussing the question of whether retort settings should have an increased amount of bracing. If one compared all English systems of carbonizing plant, apart from horizontals, one would find that the steelwork and the bracing were very much less than was customary on the Continent; and he believed that many of the defects which were found in all systems which were used in this country—and there were defects—could be traced largely to insufficient bracing, and to expansion of refractories, causing leakages after three or four years' life. In some cases settings which had had a life of only three or four years should have lasted from five to ten years. The experience of engineers in that matter would be very valuable. Contractors had their own experience, but it was not interchanged.

Breadth of Discussion Wanted.

It was the desire that at this Conference engineers should discuss problems of carbonization without any attempt being made to prove—for it could never be proved—that any one system was preferable to any other in all circumstances. There was the statement that horizontal retorts, which were not dealt with specifically in a paper at the Conference, had still their place and had been very much improved in the last 10 or 15 years; and that it was only in the very large works that one would consider coke oven carbonization, which was still static carbonization. One could not overlook also that if gas undertakings were going to progress still further they could not neglect the solid fuel aspect of the subject; and that, before they could really handle that problem and produce a satisfactory solid smokeless fuel at high temperatures, they had to face the necessity for cleaning coal before it was used. It was much worse to blend coals in a fine state of division without cleaning than to leave them as they were, as regards their future use as solid fuel. Dirty coal with the ash in large pieces did not cause much trouble to the domestic consumer; it fell out in bigger pieces, and there was very little fluff and ash flying

in the atmosphere; but a ground coal, once it was carbonized, gave an ash that was flocculent and which became a nuisance. Therefore, he urged strongly that there should be some discussion on the practicability of universally demanding and utilizing washed or air-dried clean coals.

MODERNIZED HORIZONTALS.

Mr. TOOGOOD, who has done a good deal of work recently in connection with horizontal retorts, supplemented Mr. Hardie's figures. He said that some vertical retort enthusiasts, in reading Table 1 of Mr. Hardie's paper on "Some Phases of Modern Practice in Gas Manufacture," might miss the vital qualification contained in the preamble, wherein the author had stated that Table 1 displayed the distribution of energy without taking into account the increases that *can now be obtained by utilizing the heat energy in the products*. In connection with Table 2, said Mr. Toogood, no such qualification existed, nor was it required, as the sensible heat of the coke was fully utilized and returned to the system. In connection with the tables, the speaker drew attention to what might be considered a misnomer; instead of the classification "Thermal Efficiency" and "Commercial Efficiency," he suggested it would be better to use the terms "Gross Thermal Efficiency of Conversion" and "Net Thermal Efficiency of Process," thus leaving commercial efficiency to the monetary values. Comparing horizontal and vertical retorts, and working from the figures in Mr. Hardie's tables, he said the gross thermal efficiency of conversion was 96·00 p.ct. for the horizontals and 95·84 p.ct. for the verticals. The net thermal efficiency of the process was 82·5 in the case of the horizontal, and 85·6 p.ct. for the vertical. If the heat in the incandescent coke of the horizontal retort were utilized—taking only 500 lbs. of water evaporated per ton, though many people claimed up to 700 lbs., as was the case in Mr. Bowater's paper—the efficiency of the horizontals was increased by 2 p.ct., to 84·5 p.ct., as compared with 85·6 p.ct. in the case of the vertical. Then there was the question of fuel account per ton of coal. Mr. Hardie had mentioned 3 cwt. per ton of coal carbonized; but in the paper by Mr. Barash and Mr. Finlayson, on "Continuous Vertical Retorts," this figure was acknowledged to be very high. Taking a figure of 2½ cwt., however, in the case of the horizontals—he considered this to be a liberal amount—the net thermal efficiency of the horizontal process was increased to 85·6 p.ct., which was exactly equal to that of the vertical. We could go further than that, however, because in Institution of Gas Engineers' papers recently Carr, of Stretford, had given the fuel consumption of modernized horizontals as 2 cwt. per ton of coal carbonized, and Evetts, of London, had given it as 2·75 cwt. per ton. Therefore, the fuel consumption was certainly lower in a modernized horizontal than was stated in Mr. Hardie's tables, and the average could be taken as 2·375 cwt. On this basis the net efficiency of the process was 87·34, as compared with 85·6 in the case of the vertical. Without a shadow of doubt, there was much to be said for the horizontal retort, even in these days. If we were to get this great ship "Carbonization" along we must spread our sails to catch every favouring wind that blows. Referring to the question of bracing, he said that in modernized horizontals the main arch, which had come down through a hundred years of development, had been left out, so that the need for the bracing was done away with to a very great extent. Incidentally, this had given freedom for the expansion of silica, which was very difficult to allow for underneath an arch, because if one gave a clearance under the arch it became absorbed by the expansion; then, later, the arch lifted, and there were clearances in which the retorts could expand and give trouble. With regard to grates, he considered that the bar grate was a decided advance on the step grate, because the former had no clinkering to deal with, and there was a steady flow of heat, therefore, into the setting. The chief factor of efficient regeneration being air-tightness of the flues, a 2-ply divide for tubular regenerators had been devised, which gave utmost fuel economies—viz., 2 cwt. per ton of coal carbonized. Horizontals had yet a field of usefulness in this great industry.

BLENDING AND COKE QUALITY.

Mr. H. HOLLINGS said that when considering the choice of carbonizing plant for gas-works, and with particular reference to the question of coke ovens, it should be borne in mind that, apart from the question of gas production per unit of ground area available, and apart from the question of nuisance or absence thereof in a residential area, many existing gas-works sites were unsuitable for the lay-out of a coke oven plant. The gas-works site at Ramsgate had been described, and gas engineers would have in mind many other sites which were mere strips of land bounded by rivers, railways, and high roads. No doubt more would be said at the Conference with regard to the steps taken in the design of coke ovens with a view to producing a quality of coke which was suitable for domestic use, having regard to the climate of this country. It was necessary to keep clearly in mind that the climate here was different from the climate of North America, for example, and that this in itself gave rise to a demand for coke of a different quality from that which was popular in North America and other countries. Consideration had been given to the reduction of the width of oven and to the question of blending coals prior to carbonization. He suggested that, while coke oven plant lent itself to the carbonizing of blended coals, the vertical plants, which might be more suitable for some of the more restricted sites, were also worthy of consideration in connection with the carbonization of blended coals. That was particularly true, perhaps, of the intermittent vertical plant.

Mr. JOHN ROBERTS, referring to coke quality, said his policy generally was to put the gas companies up against the coke oven companies to-day, and the coke oven companies up against the gas companies to-morrow. He had held that, for central heating purposes, oven coke was the superior of any form of gas coke. The reason was that coke oven managers generally used washed coal: but the texture of the coke was, of course, very different—one could generally distinguish between an oven coke and the horizontal, vertical, and semi-cokes with one's eyes shut, simply by the feel. The coke made in intermittent verticals was much more like oven coke than was any other gas coke. If there were a wagon load of the screened nuts from intermittent verticals and a wagon load of screened nuts from a coke oven, he doubted whether it would be possible to distinguish between them, so that the gas companies could meet the competition of the coke oven companies so far as the texture of the coke was concerned. At the moment, of course, the ash content was high, but if gas companies used cleaned coals there was no reason why they should not be able to yield a product which was equal to graded furnace coke, for central heating purposes. Then, by the simple expedient of blending, the structure of the coke could be considerably modified. Finally, he thanked Mr. Ruthven for having afforded him facilities for carrying out tests on blending.

Mr. T. F. E. RHEAD pointed out that during the war so many coke ovens were put down at the mines themselves that the country was now practically flooded with coke oven coke, and until the iron trade got on to its feet again the gas companies would have to meet the competition of coke oven coke from the mining areas, which was very serious. He personally welcomed the different systems of carbonizing in existence, and considered it a mistake to think that one system was going to oust all the others. Gas companies were gradually getting away from the idea that they existed only for the purpose of selling gas. There was a very big field for solid fuel, and in his view the gas undertakings must become the purveyors of the most suitable solid fuel in the future. That being so, it was necessary, certainly in the case of the big undertakings, to have more than one type of carbonizing plant. With regard to the relative costs of carbonizing, the question of thermal yield per ton *versus* thermal yield per retort per day depended on so many conditions, particularly in a big undertaking, that only the accountant was able to tell the engineer when he was working in the most satisfactory manner. Even in an undertaking such as that of Birmingham, it did not pay all the stations to work to the same thermal yield per ton. Very many items of expense had to be considered—wear and tear of retorts, maintenance, and so on—and the accountant would tell one plant to work in a certain way and another in another way. Mr. Hardie, in a paper he had read to the London and Southern Junior Gas Association, had mentioned a chemical control house for retort houses, and had referred to two Arkon volume recorders; Mr. Rhead asked Mr. Stewart how satisfactory those recorders had proved to be when working on crude gas from the different retort houses. Referring to Mr. Ruthven's paper, the speaker said the coals used in the tests referred to had been reduced to a standard ash and moisture content. He was not sure that this practice could be defended if the ash and moisture contents of the coal as received varied to any considerable extent. Certainly it was not safe where the moisture content varied, because moisture could not necessarily be looked upon as being an inert material in the retort; it was capable of reacting with carbon and forming water gas. The question of cleaning coal was exercising the minds of gas engineers very much at the present time. When one considered the position of the mining industry, and the large number of small mines which, if they had to go to a large expense for cleaning machinery, might shut down, one would agree that possibly some gas works might undertake to clean their own coal, and he would not be surprised if that plan were adopted to a limited extent in the future.

BRACING OF SETTINGS.

Mr. G. C. PEARSON, dealing with the question of the choice of carbonizing plant, said it appeared, from information from different parts of the country, that there were a number of plants which would give practically equal thermal yield and costs per ton. There was not a great deal of difference one way or the other, but it seemed to him that choice was restricted to a great extent by the particular type of coke demanded in the district. A good many speakers had stressed the necessity for producing good coke; while a coke might be a good coke, however, it might not be of the type that was desirable in the locality. In Birmingham, at the present time, they were making a certain type of coke which they could not get rid of at all; they were having to run water gas plant at greater cost in order to consume it, and it was very difficult to know what to do with it. Even if, in the vertical retorts, there happened to be a change of coal, and the coke produced was of a harder nature than formerly, people grumbled. Referring to the presence of bats in coke, mentioned by Dr. Smith, he said there was no doubt that the cleaning of coal was becoming essential. If the coal were ground, the ash would not be apparent in the coke, but would give more trouble in burning. But if the coke were really good, with little ash, but containing a number of large obvious bats, one would receive a large number of complaints from coke customers. Dealing with the bracing of retorts, he remarked that vertical retorts, since silica construction had been adopted, expanded to give a certain amount of trouble owing to leakage, and there was no doubt that the bracing of the settings needed to be more secure. The construction of a vertical retort was such that the joints were easily opened at the corners, and, owing to the nature of the heating of the retort, probably the temperatures at certain parts of the retort were not always the same from day to day. He was wondering whether retorts could be so made as to allow latitude in the bracing, in such a way that, when a setting was heated up, the bracing would permit the expansion that was required for the bricks to take up their new condition, and then the bracing might be permanently fixed.

Mr. TOOGOOD, referring to bracing, said that in the very first bed of continuous vertical retorts his firm had too strong bracing, and had burst tie bar. Since then they had used rather less bracing, but with lead washers underneath the nuts at the end; and these yielded and absorbed the expansion as no other adjustment could do. With regard to Continental bracing, he believed the reason why it was more severe than in this country was that the engineers there were more theoretical. A buckstay could not be calculated—there were no data on which to calculate it—and they made the bracing stronger; but they also used springs, and therefore, although the bracing was stronger, the bench was less braced because the springs yielded.

"DEMPSTER-TOOGOOD"

DESCENSION (SCRUBBER) PIPES AND MODERNIZED-HORIZONTALS

POROUS BRICK INSULATION.

STRAIGHT JOINT TO RENDER INDEPENDENT EACH SETTING.

PATENT ELLIPTICAL COMBUSTION CHAMBER ARCHES.

ALL NOSTRILS BROUGHT INTO VISIBILITY.

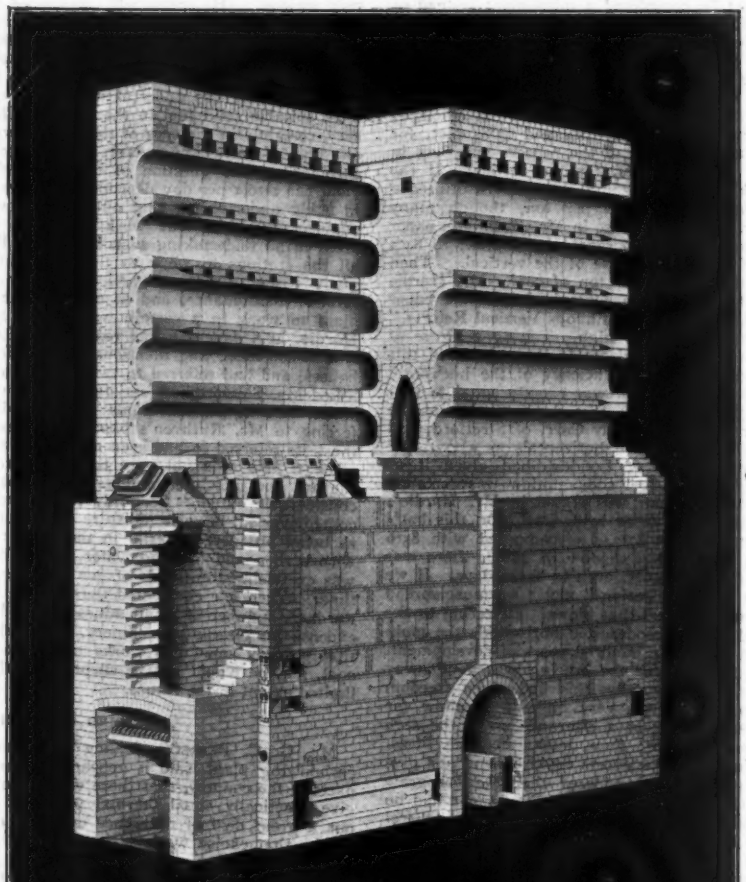
SLIDING FURNACE-CHARGING-DOOR.

CURTAIN WALL & CONSTANT DEPTHS OF FUEL.

PATENT NON-CLINKERING SCREEN-BAR-GRATE.

FURNACE CONTROLLED BY P.G. DAMPERS.

NO ASHPAN DOORS NEEDED.



SILICA EXPANSION ACCOMMODATED.

PATENT FLAT BENCH COVER. BUILT OF STANDARD SHAPES THROUGHOUT

BUILT-UP 95% SILICA RETORTS

BONDED AND INSULATED BENCH FRONTS.

PATENT 2-PLY, 2-ROW, TUBULAR REGENERATOR.

W.H. & S.A. CONTROLLED FOR EACH $\frac{1}{4}^{TH}$ LENGTH OF RETORT.

CONTRA-FLOWING STREAMS OF W.H. & S.A. SEPARATED BY 2 THICKNESSES OF FIREBRICK. ALL LEAKAGE THEREBY ENTIRELY PREVENTED.

"DEMPSTER-TOOGOOD" MODERNIZED HORIZONTALS.

FLEXIBILITY OF GAS MANUFACTURE THE SAME UNDER THE THERMAL STANDARD IN ALL TYPES OF CARBONIZATION.

1928 HORIZONTAL RETORTING STOPPED PIPES PREVENTED; ALL DIFFICULTIES OF EXPANDING SILICA OVERCOME BY SIMPLE OMISSION OF MAIN ARCH.

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Wire: "DEMPSTER" ELLAND ELLAND. 'Phone: ELLAND 261.

Commenting on Mr. Pearson's suggestion, he said he did not think it was possible to brace a bench to such exactitude, because silica grew for a long time, and more damage would be done in trying to stop the expansion than in absorbing it.

Dr. E. W. SMITH, referring to a calculation that was made in connection with expansion cavities, said it was the custom to fill those cavities with corrugated paper, or straw board, as it was called. The bracing was appropriate for that system; but it was found on calculation, and on test of the straw board, that although the texture of the material was comparatively weak, it was sufficiently strong to withstand the pressure of the expansion. Consequently, he would never use straw board for that purpose; one might just as well fill the cavities with sand or firebrick, under those conditions of bracing. If the bracing had been very strong—much stronger than was really necessary—the straw board would have been compressed, but it was impracticable to think of that type of bracing. In his view the question was not one of getting exaggerated bracing, but of getting adequate and properly distributed bracing. If one could get it more evenly distributed, instead of just calculating that so many buckstays, and so on, were needed, having no relation to where the expansion occurred, a great deal could be done, because the expansion that had caused trouble was not that which occurred at the end of five or six years—which was the period of growth—but that which occurred in the first one or two years, when slight opening-out of the retorts took place towards the bottom, where the temperature had been highest. That could have been prevented by suitable bracing in those positions.

A DELEGATE, speaking as one interested in steam production, referred to Mr. Pearson's remarks as to excess coke, and asked if that excess could not be used in furnaces specially designed for steam production, or even utilized as pulverized fuel for steam production.

Mr. PEARSON said there was no scope at the works for utilizing the coke for steam production, as all the steam required was raised by waste heat. There was also a small surplus of steam raised from coke dust.

The DELEGATE said he had in mind the selling of the excess coke for steam raising.

Mr. PEARSON replied that he would be only too pleased to sell it if he could get a market, and at a proper price.

Mr. RUTHVEN, replying to Mr. Rhead's criticism of his (Mr. Ruthven's) test results, on the ground that the ash and moisture contents of the coal were brought down to a standard basis—6 p.ct. of ash and 2 p.ct. of moisture—pointed out that his paper also gave results of tests carried out on the coal in the condition in which it was received; and he had put forward both sets of results, as a matter of interest. Commenting on Dr. Smith's reference to high thermal yields per ton and the cost per therm of gas into holder, he was not purchasing the particular coal which yielded 81 therms per ton, because it did not pay to do so. The coal being used generally gave a lower thermal result per ton, but the cost per therm into the holder was lower. Referring to Mr. Roberts's remarks as to the facilities afforded him for carrying out tests on blending, he said that those tests were extremely interesting and instructive to him; and thanks were due, therefore, to Mr. Roberts rather than to himself.

Mr. E. G. STEWART, replying to Mr. Rhead's question as to the control house at one of the works of the Gas Light and Coke Company, said he had no personal knowledge with regard to it, and was therefore not prepared to go into details. Referring to Mr. Toogood's remarks, he said he was reminded of a story of a man who, by a series of arithmetical calculations and deductions, had managed to prove to other people that they did no work at all during the year. It appeared to him that the little additions which had been made by Mr. Toogood to Mr. Hardie's original balance, for the purpose of proving that horizontal retorts were really quite as efficient as the vertical retorts, were somewhat on the same lines. [Laughter.] One could do almost anything with figures. Mr. Hardie was an honest man, as he believed would be admitted by all; and when he put forward a figure, it was such that the Gas Light and Coke Company, if they were contractors, would be prepared to guarantee. When Mr. Hardie said that they used 3 cwt. of fuel, that was the fact of it. Speaking for himself personally, Mr. Stewart said there was a good deal in what Dr. Smith had said with regard to putting forward guarantees, in respect of various plants, of figures which could be obtained with those plants if they were driven to their very utmost at the beginning, though probably that would result in injury later. The results given in Mr. Hardie's paper could be honestly guaranteed as being representative results from those plants. One aimed at something more than one expected; and what one asked of contractors was more than one got. Dr. Smith had said that guarantees asked for were such as to necessitate the ill-treatment of the plant. Surely, however, it was a matter for the conscience of the man giving the guarantees; and if a man guaranteed his plant to do something, the complement to that was that he ought to do it without over-driving. This seemed to be the answer to the point. No doubt Dr. Smith would say that would be all right if every contractor in the market could be induced to do this; but the answer he (Mr. Stewart) had given was the real answer to the question, and it also answered Mr. Toogood's point. In the course of his duties he had from time to time been engaged in investigations to find out what fuel was used for horizontal retorts; and he was perfectly convinced that the figure given in Mr. Hardie's paper was about as near the truth as one would get in regular operation.

Mr. TOOGOOD said he would not like it to go out from the meeting that he had in any way doubted Mr. Hardie's figures, and he had been careful to point out that he was supplementing them. He did not believe some of the figures that had been published with regard to horizontal retort fuel consumption, but he believed the figure of 3 cwt. was high, and a figure of 2 cwt. could be maintained in practice in a modernized horizontal.

Mr. E. B. TOMLINSON agreed with Dr. Smith's remarks as to the danger of submitting retorts to severe tests in the early part of their life. Some years ago he had had the experience of starting a house of vertical retorts. He had not pushed it, but had nursed it, and had obtained reasonable results—within a mere trifle of the guaranteed results—but those results had continued to improve steadily until the fourth year of the life of the plant. The results obtained during the fourth year were considerably above those guaranteed. He considered that to rush a system of retorts in its early days was to ask deliberately for trouble, as he did not regard the refractories as being completely burned and as having reached their final condition at that time. They must be burned and changed in their character, and improved, with due care, up to the second or third year of their life. With regard to the question of ground space per therm, or per 1000 c.ft., or per ton of coal carbonized, Mr. Tomlinson urged that gas engineers should not attempt to crowd the plant too much, to the detriment of supervision and to the detriment of the men operating the plant. The ultimate results obtained from a plant depended very largely upon the goodwill of the men handling it; and an important point was that of accessibility by the technical men who had to get round the plant and see to the heats and the proper regulation in all its phases. The house of vertical retorts which he had mentioned was originally a 6 million c.ft. per day inclined retort house, but it had made that quantity on only about two or three days in the whole of its life. At present it was making something in the region of from 13 millions to 13·2 millions per day, with a very great degree of comfort to the men handling the plant and to the technical assistants who had to look after it. In his view, one could pay too much by crowding the plant and losing in the direction of comfort of working and in ultimate efficiency.

The afternoon session was cancelled, on the suggestion of the CHAIRMAN, in order that the delegates to the conference might have an additional opportunity of visiting the British Industries Fair.

On the motion of Prof. SMITHELLS, a hearty vote of thanks was accorded Dr. Clayton for having presided.

Dr. CLAYTON briefly responded.

The conference was then adjourned until Wednesday morning.

SESSION III.—Chairman: Mr. G. A. HEBDEN (President of the Coke Oven Managers' Association).

The CHAIRMAN, in opening the session, said he was pleased to have the opportunity of meeting so many members of the Societies comprising the Joint Fuel Committee and members of industries so closely allied with the coke oven industry. They all had similar technical and commercial problems, some of which would be discussed that morning. Such conferences as these provided an opportunity for a discussion of these problems, thus arriving at a better understanding of them and also of each other. In both the gas and coking industries, there was a need for this better understanding; and if this was arrived at—and he considered the present was a good opportunity—the aim of these conferences would be fulfilled, and industry as a whole, as well as the particular industries in which they were interested, would benefit.

The following paper was then read:

THE GENERAL SCOPE OF THE COKE OVEN INDUSTRY.

By C. P. FINN and R. RAY.

DISCUSSION.

The CHAIRMAN remarked that if there were any speakers who wished to deal with the question of gas supplied in bulk, or gas distributions from coke ovens and steel works, he hoped they would make them on this paper only, as the next paper dealt more with the construction and operation of coke ovens.

Mr. W. GREEN (Manvers Main Collieries) in a written communication said there were two points in the paper upon which he wished to comment—viz., domestic coke and gas supply for town purposes. As regards the former, the quality of the coke supplied from bye-product ovens for domestic purposes was becoming more appreciated by the public. The paper by Messrs. Greenfield and Harrison particularly noted this; and further evidence of its value was to be found at frequent intervals by the ever-increasing sales which were being made. Coke suitable in every way for domestic purposes could easily be made in the modern oven, particularly when suitable coal or blends of coal were treated under proper temperature conditions. It was therefore on these lines that business should be still further extended, and the coke market treated not merely as an outlet for small screened sizes from furnace coke. The policy should be a forward one, and, by a suitable sales organization, should be pressed to its utmost limits to secure a wider market for the industry. Expansion on these lines might yet become a vital necessity, and it would certainly be an argument in fixing the price at which gas could be sold for public purposes. Coming to the question of gas supply, Mr. Green remarked that Mr. Thomas Hardie, in a paper read before the Southern Association of Gas Engineers and Managers, recently, assessed coke oven gas at 3¼d. per 1000 c.ft., or 0·7d. per therm, basing his figures on a gas-works cost of manufacture of coal gas at 1s. per 1000 c.ft. (Dr. E. W. Smith, Hon. Secretary, who read this

communication, said it was not quite true to say that Mr. Hardie absolutely assessed coke oven gas at 3½d. It was a figure put forward as a basis of discussion.

Mr. Green's contribution contended that the figure of 1s. per 1000 c.ft. was, of course, dependent mainly on the price of coal and the revenue to be derived from bye-products. According to one authority in the gas industry, ammonia recovery had now ceased to be profitable, and must be considered a purification cost. Tar prices had been falling recently, and the general tendency indicated further falls unless the road-tar market produced a recovery in the price of the crude product. This left coke in the position of main producer of revenue; and if the bye-product industry expanded in this direction, the profits to be derived from this source would eventually be considerably reduced. It might be that in the near future the tendency would be for gas coal prices to harden; and under the foregoing circumstances it would then appear to be a matter of considerable difficulty to manufacture gas at the price mentioned by Mr. Hardie. It was a curiously significant feature that the large townships which took big supplies of coke oven gas had the lowest gas selling prices. To the best of his knowledge, these concerns paid at least 6d. per 1000 c.ft. for their crude gas; and in view of this, and their public selling prices, it would appear that Mr. Hardie's statistics were not in accord with these cases. Further instances of the purchase of bulk supplies of coke oven gas by large gas undertakings had recently been mentioned; and the responsible gas engineers must feel satisfied that their views were sound financially and economically. The gas grid scheme propounded in a recent paper by Mr. F. White before the Midland Section of the Coke Oven Managers' Association was worthy of serious consideration, as there were many small gas-works where selling prices were high, which could be supplied under such a scheme with advantage both to themselves and the community. A direct instance of this had been provided by Sheffield, which had recently absorbed two small gas-works several miles apart. In fact, was not London itself one huge gas grid?

Need for a Joint Committee.

Dr. E. W. Smith said he was certain that a large number of people had views to express with regard to coke oven gas for town purposes. There was a definite need for a Joint Technical Committee to take this matter in hand and discuss it around the table; and what he strongly urged was that, instead of bandying figures through the Press, it would be much better to get together and come to some conclusion as to a basis of discussion, as to what the possibilities were in the use of coke oven gas. The coke oven industry must appreciate that gas undertakings to-day, when taking all costs into consideration, were able themselves to produce gas at under 2d. per therm, and the coke oven industry could not expect to have the full use of the selling organization, the capital, and the advantage of working through an industry which was itself very closely restricted by Government ordinances. The coke oven industry could not get these advantages without bearing a fair share of the charges—in fact, all the necessary charges in connection with that industry. It would not be practicable or feasible or just—nationally just, not just to the gas industry—for the coke oven industry to take the plums of the big consumptions on which the gas industry depended, and for the gas industry to do all the propaganda work and all the development work and most of the technical work which encouraged these people to use this particular gas. The only possible way for the two industries to get together was for the coke oven industry to realize where the difficulties of the gas industry were, and to come to an equitable arrangement. Sheffield had proved that it was possible to use large quantities of coke oven gas, but each city had to be taken as a special case, and its conditions studied. If that were done, there was not the slightest doubt that in most of the cases where coke oven gas was available it would pay handsomely under proper conditions of control, such as the recent Sheffield contract, to use coke oven gas. The coke oven people would have to give the necessary guarantees—which he knew they were prepared to do—to ensure continuity and stability of supply. Therefore, surely it was possible for someone to discuss the subject from that point of view.

Mr. R. H. Ruthven (Ramsgate Gas Department) said that Mr. Green in his communication had stated that ammonia was now a purification cost. As a matter of fact, it was still a credit, though not so large as it used to be. Again, as regards tar, in the South of England they were still receiving as much for tar as three years ago; and it was as much as the tar was reasonably worth for its purpose. Another point to be borne in mind was that, whereas the cost of gas manufacture was a decreasing figure, the cost of distribution was an increasing figure all the time, and must continue to increase, in view of the increasing liabilities with regard to maintenance of consumers' appliances and the multitudinous other small costs which were being added. It was only because the cost of gas into the holder was being decreased that it was possible to reduce the charge to the consumer.

Continuity of Supply.

Mr. J. W. Brearley (Swinton and Mexborough Gas Board) said he had been taking coke oven gas for nine years, and was specially interested in the paper because Mr. Finn supplied the coke oven gas to his undertaking. As to the coke oven people supplying industries in the immediate neighbourhood of their works, the gas undertakings themselves would do it if the coke oven people would supply the gas at a suitable price, and guarantee a continuous supply. For instance, in 1919 he commenced taking coke oven gas, and immediately afterwards he offered unpurified gas direct from the coke oven gas main to a glass works, consuming approximately 80 million c.ft. per annum, at 1s. per 1000 c.ft. He himself was paying 9d. The first question asked was whether continuity of the gas supply could be guaranteed, and his reply had been that he would guarantee it if the coke oven gas people would do so. But the coke oven people could not, and the proposition fell through. He was afraid that the coke oven people would be up against this difficulty in every case. They must be able to guarantee the supply for 24 hours a day, 365 days in the year. He himself was up against it, and had unsuccessfully tried to get coke oven gas into industrial places. The continuity of supply, however, was the stumbling block. The recent Sheffield agreement was a very good one; but were all the other coke oven gas people prepared to give the same agreement? If they were, then the gas industry could supply the gas, provided they got it at a reasonable figure.

Dr. E. W. Smith remarked that Mr. Helps had the following advertisement in the Birmingham daily paper; and though perhaps it was not a matter that need be mentioned at the conference, it was worth some notice:

TOWN GAS AT LESS THAN HALF USUAL CHARGES.

Cheaper Fuel—Cheaper Power.

To all public-spirited men who really wish to serve the country, to Birmingham and other Chambers of Commerce, &c.

At the present moment at the British Industries Fair many scientific men are discussing all sorts of problems concerning cheaper fuel, under the head of "Carbonization."

I am not attending these discussions because I have passed the talking stage. I have proved by ten years practical work that the present system of the manufacture of rich gas costs nearly three times as much as commercial gas.

"When the whole world is wrong, the whole world make wrong right." (Count Mirabeau.)

At Nuneaton, town gas manufacturing processes can be seen in operation, and the resultant gas is in use by 6000 users for all sorts of purposes.

Such gas can be supplied to large users at under 4d. per therm. What are large users of gas paying in Birmingham and other places?

Motor engineers, foundries, and other large users of power and heat requiring factories are likely to find in Nuneaton the price of gas for quantities less than half that charged anywhere else in the country.

Inquiries solicited from all interested, particularly those who visualize the effect on the country's trade of coal on tap in the form of gas at about 3d. per therm.

Dr. Smith said he had one comment to make on that advertisement. There was a very useful pamphlet in reply to it, issued by the "Gas Journal," price 3d. The answer to the point made was that there were cities in this country where gas was being supplied at about 3d. per therm—which was less than the 4d. mentioned. Moreover, it was indicated by Mr. Helps that he had been working this process for ten years; but in spite of ten years' experience in Nuneaton, a village—because it could be called little else—next to Nuneaton, and with a smaller population, was supplying gas at approximately half that charged in Nuneaton. The consumption was practically double that per consumer in Nuneaton, and the output of gas was increasing at a much greater rate than in Nuneaton. These facts spoke for themselves; and on behalf of gas engineers and coke oven managers, who were trying to sell gas at a cheap rate, he thought it opportune to make these facts clear.

The Author's Reply.

Mr. Ray, replying to the discussion, said he was somewhat disappointed that there had not been a more vociferous condemnation of the principles put forward in the paper. Mr. Green had spoken of domestic fuel and gas. The coking industry in recent years had unquestionably taken a keen interest in the domestic fuel market, not, as had been suggested, because of the very great trouble in disposing of their solid product, but because they looked forward in the future to offering a product which would in every way be as good as, if not better than, gas-works coke. To-day, in the majority of instances, he admitted that the coke oven industry did not supply a domestic fuel which was as good as gas-works coke; but, as had been demonstrated within the past twelve months, with the erection of modern plants specially designed for the purpose of producing these solid smokeless fuels, the coke oven industry was confident that a product would be put on the market not only as good as gas-works coke, but, from the point of view of combustibility, cleanliness, and moisture content, better than gas-works coke. He suggested to his friends in the gas industry that if in the future they desired to prevent the coke oven people from making further inroads into what the gas industry thought was its special field, then they would have to set their own house in order, and clean their coal before carbonization. Mr. Green had also mentioned that Mr. Hardie had made a certain statement regarding the figure which he considered a fair one for coke oven gas. He personally, until yesterday, had been inclined to object very strongly to the wording of Mr. Hardie's statement; but after hearing the explanations of various mutual friends with regard to the matter, he felt that possibly those on the coking side had tended to misconstrue Mr. Hardie's meaning. It had been pointed out to him that the figure of 3½d. per 1000 c.ft. mentioned by Mr. Hardie was taken merely as a basis for argument. It was, he believed, expressed "in the order of 3½d. per 1000 c.ft." That might be so, and he was prepared to accept the explanation. On the other hand, he was bound to suggest that it was decidedly unfortunate that a gentleman occupying the position Mr. Hardie did in the technical world, and a man who was very widely known and respected in the gas industry, should have made use of that figure of 3½d. on this occasion, because it was not a fair figure in any circumstances for coke oven gas bought by a public undertaking. In special circumstances, where crude gas could be sold direct to industrial concerns which required large volumes for their smelting furnaces, he agreed that it would then be a proposition, or at any rate that the proposition was a different one. If, for example, a coke oven company could sell half its total output of surplus gas to a gas company at what would be considered a reasonable figure on both sides, it could well afford to come to an agreement with an industrial firm, through a gas company if necessary,

for the sale of crude gas to that industrial concern at such a figure as had been mentioned by Mr. Hardie. He would like to see Dr. Smith's suggestion followed up, so that, instead of talking in conferences and before Commissions, and in public generally, each from his own individual standpoint, a few of those on both sides who had this subject at heart would consider the problems together. Unquestionably conferences such as these were helpful; but it was not possible in this way to get down to hard facts. If eminent men on either side would take up this suggestion, then the difficulties, and what he would call antagonism, for want of a better word, which might exist between the two great carbonizing industries would to a very large extent be eliminated. He would like to take this opportunity of saying how those in the coking industry had appreciated the efforts made by certain gas engineers in the North, who in every way had proved themselves useful and helpful to the coke oven people in disposing of coke oven gas. In the latest agreement with Sheffield, for example, in which he was particularly interested, many of the difficulties which had been mentioned had been smoothed-out. On the question of continuity of supply, it had been agreed by the coke oven people to keep a very large stock of coal, and, further, in the case of a national stoppage, when that coal might in due course be used up, it had been agreed to buy coal from abroad or from any other source possible, in order to continue the supply of gas. It had also been agreed that the men working on the plant should be carefully chosen—men who were not particularly red in colour, or who, possibly, were not members of unions, or men who would be prepared to join the Gas-Workers' Union—so that, as far as reasonably possible, the endeavour had been made to take all precautions against a breakdown of supply in an emergency. Again, as regards price, once a basic figure had been established, he did not think there should be any insuperable difficulty in coming to agreement in that respect. The price of the gas ought to be regulated on a sliding scale based on the price of gas coal. This was only fair to the gas side, and it was an equitable arrangement from the coke oven point of view. Dr. Smith had mentioned the fact that the coke oven people could not expect to get all the advantages of the organization of public gas companies without having to pay for them. That, up to a point, was a perfectly reasonable statement. On the other hand, looking at the question purely from the point of view of the future of the coking industry—which it would be agreed was in a somewhat unfortunate position at the moment—if the coking industry was to be rehabilitated, if it was going to produce coke, which was the principal product of the industry, at a price which would assist their friends in the iron and steel industry to make ends meet and put them in a position to compete with their Continental neighbours, it would be necessary to build, where possible, coking plants for mass production of coke. This, he believed, would be agreed. It would then be necessary to find an outlet for the gas. If such an outlet could not be found, then such large-scale coking plants would not be economic propositions. Was the coking industry of the country, therefore, to be let down, was it to be allowed to fizzle out, followed, of course, by the iron and steel industry, which would also have an unfortunate effect on the colliery interests? Were the coke oven managers to allow this position to develop without making a bid? A bid could only be made if they tried to sell their gas, and developed to the utmost extent the solid fuel market, and so on. He did not think it was unreasonable that they should do so, but he would be the last to suggest that they should poach on the prerogative of the gas companies for the sale of purified gas. At the same time, he maintained that the statutory obligations of gas undertakings should be of a sufficiently elastic nature to enable the coke oven people to supply crude gas for industrial purposes direct. In many cases he did not think this would be necessary. In Sheffield, he thought, it would be unnecessary because of the good feeling and understanding which existed; but there were other areas where such good feeling did not exist, and the coking industry was being definitely held up as the result of such antagonism. In all probability, however, these difficulties could be smoothed-away if a round table conference, as suggested by Dr. Smith, could be arranged. Mr. Brierley had mentioned the question of continuity of supply. This had been dealt with in his previous remarks, but there was one point concerning continuity of supply, apart from labour troubles or trouble in the coalfields or lack of coal stocks. The coke ovens depended upon one other factor, and that was the volume of gas taken by gas undertakings or industrial concerns. It was obvious that in times of national stress it could never be possible to keep a large battery of ovens going if, for example, the volume of gas required was only of the order of 200,000 to 500,000 c.ft. a day. This was a different proposition from three or four million c.ft. per day. A modern battery was one capable of producing normally 8 to 10 million c.ft. of gas per day. If half that output was sold, then unquestionably continuity of supply, on the basis of the most recent agreement, could be maintained, and would be maintained willingly; but when the quantity became relatively small, the position was entirely different. However, if the two great carbonizing industries could come together in the manner suggested, it would be of enormous benefit to both sides.

[COMMUNICATED.]

Mr W. GREEN writes: There are two points in the paper "The Scope of the Bye-Product Coke Industry," by Messrs. Finn and Ray, on which I would like to comment—viz., domestic coke and gas supply for town purposes. In regard to the former, the quality of the coke supplied from bye-product ovens for domestic purposes is becoming more appreciated by the public.

In the paper by Messrs. Greenfield and Harrison, this point is particularly noted; and further evidence of its value comes to hand at frequent intervals by the ever-increasing sales which are being made.

Coke suitable in every way for domestic purposes can easily be made in the modern oven, particularly when suitable coal or blends of coal are treated under proper temperature conditions. It is therefore on these lines that business should be still further extended, and the coke market treated not merely as an outlet for small screened sizes from furnace coke.

The policy should be a forward one, and, by a suitable sales organization, pressed to its utmost limits to secure a wider market for the industry. Expansion on these lines may yet become a vital necessity; and it would certainly be an argument in fixing the price at which gas could be sold for public purposes.

This brings me to the question of gas supply. Mr. Thomas Hardie, in a paper read before the Southern Association of Gas Engineers and Managers recently, assessed coke oven gas at 3¼d. per 1000 c.ft., or 0·7d. per therm, basing his figures on a gas-works cost of manufacture of coal gas at 1s. per 1000 c.ft. This latter figure is, of course, dependent mainly on the price of coal and the revenue to be derived from bye-products. According to one authority in the gas industry, ammonia recovery has now ceased to be profitable, and must be considered a purification cost.

Tar prices have been falling recently, and the general tendency indicates further falls unless the road-tar market produces a recovery in the price of the crude product. This leaves coke in the position of main producer of revenue; and if the bye-product coke industry expands in this direction, the profits to be derived from this source will eventually be considerably reduced.

It may be that in the near future the tendency will be for gas coal prices to harden; and in the foregoing circumstances it would then appear to be a matter of considerable difficulty to manufacture gas at the price mentioned by Mr. Hardie. It is a curiously significant feature that the large townships who take big supplies of coke oven gas have the lowest gas selling prices. To the best of my knowledge these concerns pay at least a minimum of 6d. per 1000 c.ft. for their crude gas; and in view of this and their public selling prices, it would appear that Mr. Hardie's statistics are not in accord with these cases. Further instances of the purchase of bulk supplies of coke oven gas by large gas undertakings have recently appeared, and the responsible gas engineers must feel satisfied that their views are sound financially and economically.

The gas grid scheme propounded in a recent paper by Mr. F. White, before the Midland Section of the Coke Oven Managers' Association, is worthy of serious consideration, as there are many small gas-works, where selling prices are high, which could be supplied under such a scheme with advantage both to themselves and to the community. A direct instance of this has been supplied by Sheffield, which has recently absorbed two small gas-works disposed several miles away. In fact, is not London itself one huge gas grid?

The next paper was:

MODERN COKE OVEN PRACTICE.

By G. J. GREENFIELD and G. H. HARRISON.

DISCUSSION.

Mr. JOHN ROBERTS (H.M. Office of Works) called attention to the width of oven mentioned in the paper—viz., 18 in. for the new battery. He would not question the wisdom of this; but in view of the attention that was being devoted to the production of domestic coke in coke ovens—and by that was meant a free-burning coke—it seemed that they should hesitate before deciding to adopt 18 in. for the ovens, seeing that the coking time was increased from 11 hours with the 14 in. oven to 15½ hours with the 18 in. oven. This meant that the coke nearest the walls would be subjected to a temperature of approximately 1000° C. for a 40 p.ct. longer period; and this, in his opinion, would reduce combustibility.

USE OF SILICA.

Mr. WALLIN said he was in agreement with practically everything stated in the paper. The authors were evidently greatly in favour of silica ovens, but at the same time they pointed out that fears had been expressed as to the expansions which might take place. The silica oven, however, was by no means a new departure. Such ovens had been operating for 18 years, and it seemed rather difficult to understand why this particular point should now be raised. A point which should be stressed was the importance of providing collecting main regulators, automatic conveyors, and recording instruments. His experience had shown this to be most important if regularity of working was to be secured. For instance, working in this way with 17 in. ovens, the calorific value of the gas over a long period did not vary by more than 2 p.ct.; the sulphate was within ¼ lb. from month to month; the tar yield was within half-a-gallon; and the benzole yield was within one-tenth gallon. These were averages of monthly figures and were secured through the use of sufficient automatic controls and recording instruments. He had been very much interested in what the authors had said about the nursing of coke. Too often there was a tendency to handle the coke too gently, but the proper place to make breeze was at the ovens, and not in the blast furnaces. As to the cost of repairs, he could corroborate the statement that a modern silica oven, well designed and properly constructed, would give its operators and owners absolutely no trouble whatever. Another point was the number of B.Th.U. required to carbonize 1 lb. of coal, but the authors' mention of several very low figures in this respect required some explanation. Was it not a fact that on the Continent the B.Th.U. consumption was calculated on the net B.Th.U. value of the gas, while in this country and in Canada and America the calculation was made on the gross value? Another possible reason for the lower figures on the Continent was the nature of the coal being carbonized. For instance, in connection with the Droucourt installation, some temperatures had been taken which showed that they were carbonizing a coal with 8 p.ct. of moisture in a 16-in. oven 17 hours at a temperature of 1120°; but he was absolutely convinced that carbonization of Nova Scotia coals containing 8 p.ct. of moisture in a 16-in. oven at 1120° could not be carried out in less than 22 to 24 hours.

HEAT BALANCES.

Mr. N. D. LEES said that the tendency of modern coke oven construction was in three directions—viz., increased output, reduced

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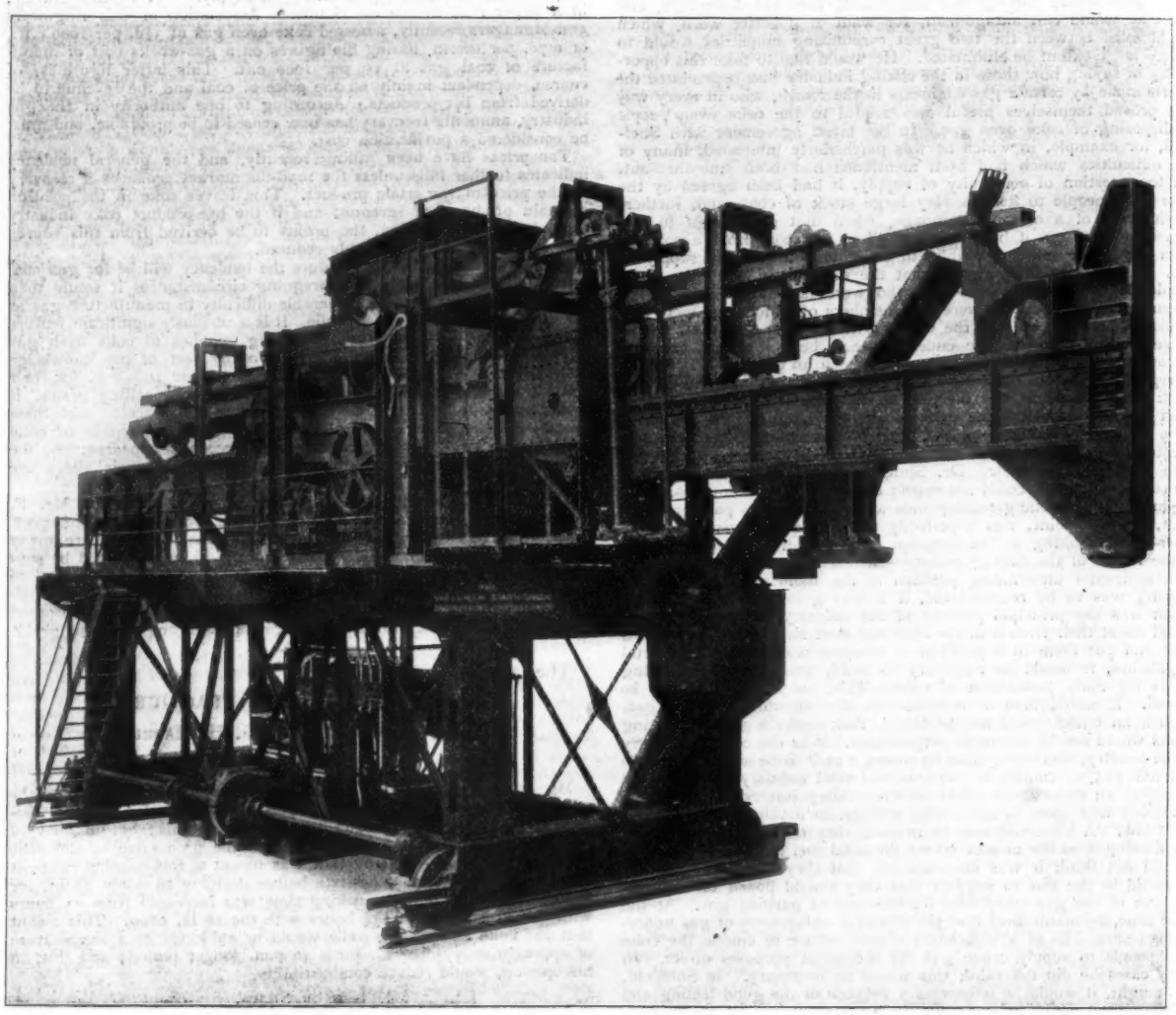

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labour, and diminution of heat consumption. Before it could be determined how much heat could be saved in carbonization, however, it was necessary to draw up a balance-sheet for the carbonization process; and he had constructed one, very roughly, because the figures were liable to variation according to the coal being carbonized and the particular conditions of working. Roughly, however, of the heat of the coal being carbonized, the figures were as follows: 67 p.ct. in the coke; 14 p.ct. in surplus gas; 11 p.ct. in fuel gas; 3 p.ct. in the sensible heat of the coke; 1 p.ct. in the sensible heat of the gas; something under 1 p.ct. in bye-products; and the remainder, about 3 p.ct., for radiation and other small losses. By considering such a balance-sheet, it was possible to get some idea as to how the heat could be reduced. There were in existence several processes for recovering the sensible heat of the coke. He had in mind particularly the dry cooling process, which had been referred to by Mr. Greenfield; but only 3 p.ct. of the total heat of the coal was recoverable in that way. Of the heat 11 p.ct. was consumed by the ovens themselves; and it was clear that it was in this direction that the biggest economies could be hoped for. It was necessary to reduce the temperature of the gas going to the chimney; and this could only be done by greatly increasing the regenerative capacity of the ovens.

HIGH-SPEED OVENS.

Mr. L. H. SENSICLE said that, though the authors did not deal with the high-speed plants in America, it was interesting to have the information contained in the paper. The authors pointed out that with the 18-in. oven and a longer carbonizing period, the coke had been found to be more even in texture. Reference had been made to the tendency to adopt wider ovens. Perhaps this was due to the fact that the coke in the narrower ovens resembled gas coke, and was not suitable for blast furnace purposes. He was interested in the suggestion of the adoption of coke ovens for gas-works practice. Perhaps the solution would be the narrower oven for gas-works practice, and a medium width oven for coke oven practice. The figures given for the breakdown period were remarkable, and reflected great credit on those concerned. It was remarkable, too, that the calorific value did not fall below 520; and this seemed to be an answer to those people who argued that coke ovens could not be relied upon to produce gas of a steady quality. Some figures were given in the paper for 14-in. ovens with a coking period of 11 hours and giving a throughput of 30·5 tons per day. It had interested him to work out the quantity of gas made from a battery of fifty such ovens with Durham coal yielding 13,000 c.ft. per ton. The quantity of gas would be 19½ million c.ft. per day, and the length of the battery would be less than fifty yards.

Dr. E. W. SMITH said he had had some figures taken out relating to best-quality silica, and he thought they would give some confidence concerning the materials available at the present time. The figures related to three leading makers, and the tests had all been carried out on material supplied since May, 1927. The first maker produced a silica brick which, according to the Gas Engineers' specification, should not have had an expansion of more than 0·5 p.ct. Actually, on 26 different samples, the expansion was only 0·11 p.ct. The second maker, on 21 samples, showed an expansion of not more than 0·03 p.ct.; and the third maker, as the result of ten tests, had a figure of 0·13 p.ct. The expansion was always the critical test, as the fusion test was generally satisfactory. He therefore thought it could be taken that silica materials could be produced now, both for coke ovens and gas undertakings, which were entirely satisfactory if properly used. All the tests were at 1410° C.

Mr. T. F. E. RHEAD asked if the tests were only carried out at 1410° C., as some makes of silica would pass this test but fail at 1500° C.

Dr. SMITH: The tests were carried out at 1410° C.

THE AUTHOR'S REPLY.

Mr. GREENFIELD, in reply to Mr. Roberts, said that if he were asked to prescribe coke oven plant for gas-works, he should suggest 12-in. ovens. He thanked Mr. Wallin for the support he had given to the paper. With regard to his comments concerning the doubts in respect of expansion of silica bricks after they had been in use for 18 years in America, well, the English were noted for their conservatism. He agreed with Mr. Wallin on the question of instruments on the plant. The rather formidable list of instruments mentioned in the paper referred to a bye-product plant; and though the authors recognized it was a big list, they thought it was justified. As to the nature of the coal affecting the heat consumption, it was necessary to be careful in comparing one coal with another. With regard to the question of short delays, mentioned by Mr. Sensicle, it was obvious that it was not desirable to stop the regular outflow of heat from the battery, because otherwise there was an accumulation of heat in the battery, and in the course of a few hours a great deal of damage could be done. Therefore, it was the major part of the job to keep delays as small as possible, and prevent them if feasible. At any rate, unavoidable delays must be kept as short as possible. Mr. Sensicle had referred to an imaginary battery which would occupy a space of not more than 50 yards; but without going into the figures in detail, it occurred to him that there was some bad arithmetic for which he would be partly responsible if Mr. Sensicle's figures really followed from what was in the paper. Dr. Smith had given some interesting information with regard to the thermal expansion of silica bricks which enabled him now to make a remark with regard to what Mr. Toogood had said the previous day about silica bricks growing for four years. The battery mentioned in the paper grew 6½ in. between back and front within two months of the time the battery was started-up four years ago, but at the beginning of April last, when the measurement was taken, the growth was still 6½ in. Therefore, he thought it depended upon joints, and perhaps the bricks themselves, as well as, perhaps, the way the battery was run. It might also depend upon the construction of the vertical retorts.

The final paper of this session was:

COKE RESEARCH AND THE STEEL INDUSTRY.

By E. C. EVANS.

DISCUSSION.

Dr. W. T. K. BRAUNHOLTZ (Armstrong College, Newcastle-on-Tyne) said that the author, in his résumé of the paper, had spoken mainly of blast furnace reactions, but in the printed paper not much had been said as to the testing of the mechanical condition of coke for blast furnace use. It had been mentioned that the shatter test appeared to be the best they had of the blast furnace value of different cokes, assuming that the chemical analysis was in all ways suitable. The shatter test was undoubtedly a most valuable one, inasmuch as it gave an idea of the extent to which coke would break down in its passage from the ovens to the furnace; and this test had in the past given valuable information, with the result that perhaps its merits had been exaggerated. There were people who considered it the alpha and omega of coke testing, which it had never professed to be and obviously never could be. There were so many other factors. The mechanical strength test of coke which was used very largely on the Continent consisted of placing the coke in a drum and rotating it so many times, but the shatter test was rarely used abroad, whereas the drum test was rarely used in England. Nevertheless, before they accepted the shatter test as the best test of mechanical strength of coke, they ought carefully to consider the drum test and its possibilities. In Newcastle this was being done—and others were doing the same; and the drum test had this merit, whatever defects it had, that it did give a measure of abrasion, whereas the shatter test did not. Experiments that had been carried out at Sheffield on the abrasion of coke had shown, in the first place, that it was small in extent, and secondly it appeared to bear no direct relation either to the shatter test or to the blast furnace value of coke. It was conceivable that two cokes which gave the same shatter indices, might prove totally different under abrasive tests. Therefore, the German test was worth further investigation. The question of the porosity of coke had been touched on in the paper; but at the present moment the only method of determining this was to ascertain the so-called total porosity. They would not get very far while they restricted themselves to such determinations, because it was possible to get the same total porosity from a small number of large pores as from a large number of small pores, yet the behaviour of the two cokes in a furnace might be quite different. The Northern Coke Research Committee had started some work to determine the relative proportions of large and small pores in coke; and a method would be published shortly, which, however, did not profess by any means to be the last word on the subject. Some mathematical expression of the pore structure was needed. Rose's method of sectioning gave a visual method of comparing the pore structure, and also indicated the degree of fissuring of different cokes upon which, presumably, the mechanical strength depended. It also gave a picture of the homogeneity of a coke; but he would like to give a word of warning with regard to this method. In the Rose sections there were pieces of black material which were usually considered to be dirt or shale, but it was necessary to be careful in interpreting this too strictly, because he had examined various cokes in this way and had found that the dirt particles in some cases might contain 50 p.ct. or 60 p.ct. of ash, and in other cases only 25 p.ct. This might indicate particles of non-coking coal or cannel; and to jump to the conclusion that these black particles were ash might lead them far astray. As to the reactivity of coke, Mr. Evans had stated that he did not think there was any connection between the reactivity of coke towards CO_2 and its value in the blast furnace. It was true that they did not know much about it, and it was possible that reactivity *per se* was not a very important factor, and that some other factor upon which reactivity depended was more important. Work at the Fuel Research Station on coke ground to the size 10/20 mesh I.M.M., work at the Midland Coke Research Committee's station in a fairly large furnace, and work by the Northern Coke Research Committee on coke of 5/10 mesh I.M.M. in an ordinary silica tube—all had led to the same conclusion—that the cokes with the least reaction to CO_2 were those which in practice were the most valuable in blast furnace use. When three methods very different in their details all pointed in the same direction, it was at least significant.

ADVANTAGES OF COAL CLEANING.

Dr. R. LESSING said he had been prevented from being present during the discussion on Messrs. Greenfield and Harrison's paper, and the point he had intended to make in speaking upon it had been answered by Mr. Evans in his paper. The question arose on the following statement in Messrs. Greenfield and Harrison's paper: "In cases where it is considered advisable to leave the stone in the coal, a solution to this difficulty is to use a roll crusher so as to reduce the size of the stone particles equally with that of the coal particles." He could not conceive there were any conditions in which it would be desirable to leave the stone in the coal, and this brought him to the text of the remarks he wished to make—viz., the question of ash in coal. Mr. Evans had shown definitely, on the basis of statistical evidence, that wherever ash was high the coke was bad. The coke was not, in these circumstances, efficient in practice; and therefore the removal of the mineral matter from the coal in the first instance was a *sine qua non* for the production of a good coke. Not only was this so from the quantitative point of view, but a great many of the questions, he felt confident, raised in connection with reactivity, combustibility, and so on, were closely bound up with this question of ash. He was certain that when they came to prepare cokes with ash content much lower than those common to-day—even those which were considered the best—it would be found that a number of these questions would solve themselves. In this connection one statement made by Mr. Evans was particularly apposite—viz., "... the effect of ash removal might easily far exceed

that which could be calculated from the knowledge only of the reduced slag volume resulting from its use." This put in other words a statement he himself had made on many occasions, and also in the discussion on Mr. Gill's paper at the Iron and Steel Institute meeting last year—viz., that the calculated monetary advantage of the removal of every percentage of ash would not be in direct ratio to that percentage, but would be in an increasing ratio. They would find that for every 1 p.ct. of ash taken away from the coke, there would be obtained a multiple of that quantity in advantage in blast furnace operations. It was stated in Messrs. Greenfield and Harrison's paper that the dry cleaning of coal depended upon differences in specific gravity. The whole problem of the cleaning of coal—and this seemed to be at the bottom of the coke question—was in two main directions to-day. One was by wet washing, and the other by dry cleaning. In both cases, there were two factors to be dealt with—viz., size and specific gravity—and any one process based on these two factors would of necessity have to strike a mean which, under optimum conditions, gave an average result. In other words, there were two factors neither of which could be eliminated. In the future, however, they would have to try to devise means by which only one of these factors would be used. In that case they would come to the absolute minimum which was possible; and according to the statement of Sir Alfred Mond at the last meeting of the Institute of Fuel, they were not far from achieving that problem, because Sir Alfred had referred to cases in which the ash could actually be reduced to 2 p.ct. Once this was done, a great many of their troubles in coke production, and therefore in blast furnace work, would be eliminated.

Mr. John Roberts (H.M. Office of Works) said that the author appeared, in his investigations upon the properties of coke, to have omitted a very important point—viz., the temperature of carbonization. It had been suggested by experts on coke production, Koppers and others, that coke for blast furnaces should be made at a temperature of from 650° to 800°. This question needed investigation. If that temperature was suitable for the production of blast-furnace coke, it certainly was suitable for domestic coke. There was a reference to this matter in his own paper before the conference. Another point was heat input per pound of coal carbonized. What he would like to have borne in mind was that when coal was put into a retort, this did not start the carbonization process. Nature had previously started it; and they were only taking the matter up where nature had left off. In the case of the Drocourt coal, it could be seen by inspection that this coal had been partly carbonized *in situ*, and the coal had 27 or 28 p.ct. volatile. If the volatile was higher, as he believed it would be in the case of Nova Scotia coals, he should imagine that much more heat would be required. Nature had already eliminated part of the volatiles in some coals, and therefore less heat would be required in the carbonization process.

Mr. G. J. Greenfield said that, when the figures of throughput in blast-furnaces were put in the paper by himself and Mr. Harrison, he expected to be taken up; but he did not expect to come up against an authority like Mr. Evans. In connection with the plant at Consett, the blast-furnace manager had at first been sceptical about the new coke, although not antagonistic. After a year or two of working with the new kind of coke the blast-furnace manager had expressed annoyance because he was getting the coke from the other plants while some of the fast-burnt coke was being sold outside, and he could not keep up the output of the blast furnaces with the slower-burnt coke. Mr. Evans's figures showed that at Consett, with increasing output, the fuel consumption went down; and the fact was—as testified to by the statements of the blast-furnace manager—that he was getting greater throughput with the 15½-hours coke from the new plant than with the 27-hours coke from the old plant. His idea, of course, was to maintain as high an output of pig iron as possible from the furnace, and these results were obtained notwithstanding the fact that the shatter test gave a little less than for the slow-burned coke. He was astonished that a man of the scientific and educational character of Mr. Evans should propose a test in inches. The Americans devised this test—he was very sorry for the Americans—but the metric system was the more rational one; and he hoped that when the modification was made which would be needed in the shatter test before it was universally accepted, Mr. Evans would use his influence to get it changed over to the metric system. With regard to the sentence in the paper by himself and Mr. Harrison, quoted by Dr. Lessing, all he could say was that it was put in deliberately in order to get some information on the matter as to whether, when the ash was reduced below a certain amount, the coke got weaker. At present it was not known whether this was so.

The Author's Reply.

Mr. Evans, replying to the discussion, said he did not suggest that the shatter test was the alpha and omega of coke testing. It would be interesting if Mr. Greenfield could give the analyses of the cokes to which he had referred.

Mr. Greenfield said he had not them; but the difference between the ash content, in the figures given to him, was 1·1.

Mr. Evans said he had had four samples of cokes made in the Consett batteries, and the difference in the analyses of these cokes was sufficient in itself to account for the different rates of driving that had been experienced. He hoped to contribute in writing further to the discussion on this point; but that was the position. When comparing cokes on their shatter test indices, it was no use saying one coke was better than another because it had a higher or a lower shatter index. All the factors must be taken into consideration. As far as the shatter test being measured in inches was concerned, he was not responsible for it, and used it as it stood at present. It was for the research committees to devise a perfect shatter test or its equivalent. Dr. Braunholtz had mentioned reactivity; but the paper had been careful to state that it was not yet possible to analyze the position completely, as so many factors were involved. He would not follow Dr. Lessing, except to mention one point. He would agree that increasing ash content was accompanied by increasing difficulties in blast furnace operation, but Dr. Lessing must be logical, and consider the possibility that decreasing ash content below a certain point might be accompanied by a resultant decreasing fuel economy. When they spoke of an ash content of 2 p.ct., they must also allow for the possibility that a decreasing ash content would be accompanied by a decreasing fuel saving.

Dr. Lessing: That is only provided there are no other factors.

Mr. Evans said that this, of course, was the whole point. He was sorry he had not mentioned the temperature of carbonization in the paper, but that was outside the terms of reference.

The Chairman in bringing the session to a close expressed the thanks of the conference to the authors of the papers, and said that in connection with the World Power Conference to be held in London in September, he hoped there would be further papers on the subjects discussed.

[Communicated.]

Mr. C. E. Wallin writes: Mr. Evans's paper is very valuable in showing the increased interest which is being taken in the production of a satisfactory blast furnace fuel; and he has covered a number of possible tests which will give some indication of this. Among others, he has devoted considerable attention to the Shatter test. It may be pointed out that, although it is relatively easy to do laboratory tests to determine any one factor which may have an effect on blast furnace operation, it is a much more difficult task to correlate laboratory tests with actual blast furnace operation, as, owing to the fact that blast furnace operation can be materially affected by so many factors, comparative tests over short periods are valueless. The modern coke oven, on the other hand, scientifically controlled and operated, can be relied upon to give a relatively constant quality of coke, provided that the same coal is used. Having had the experience of making daily Shatter tests on coke, and being able to compare these results with blast furnace operation, it is my opinion that the Shatter test is of no value except as an indication of constant coke quality, and this only when carbonizing the same coal at the same temperature in the same ovens. Beyond this point our experience was that the Shatter test afforded no useful purpose, and might even lead to erroneous conclusions.

The coal in question had a volatile content of about 35 p.ct., and was normally carbonized in 17 hours in a 17-in. oven. The coke contained approximately 0·75 p.ct. volatile matter. Under these conditions, the Shatter test would average 54-56. However, on lengthening the coking time, it was invariably the case that the Shatter test would rise sometimes as high as 62-64; but no improved operation of the blast furnace resulted, rather the reverse. We also had the opportunity of making a test extending over ten weeks, and involving the consumption of nearly 50,000 tons of coke, in which the coke was made from a mixture of 20 p.ct. of a low volatile coal mixed with 80 p.ct. of the high volatile coal. The effect on the coke at the ovens was immediately apparent. It had increased in size, was of a blocky nature, and practically all cross fractures had disappeared; and, as might have been anticipated, the Shatter test increased considerably, being now 67, instead of 56. Contrary to our expectations, the blast furnaces actually lost production on this coke, and the coke consumed per ton of iron increased; and on returning to the apparently inferior coke, normal conditions at the blast furnaces resumed. This test was very carefully followed-up by observers both in the coke ovens and in the blast furnace departments, and all weights, temperatures, &c., were carefully checked.

As a further instance, one has the example of the blast furnace at the Columbia Steel Plant, where a furnace rated at 350 tons of iron a day is producing over 400 tons a day, although the coke supplied to the furnace contains only 17 p.ct. above 1½ in.

SESSION IV.—Chairman: Mr. J. TERRACE (Vice-President of the Institution of Gas Engineers).

The first paper to be presented when the Conference was resumed on the afternoon of Thursday, Feb. 23, was:

THE INTRODUCTION OF BLUE AND CARBURETTED WATER GAS IN VERTICAL RETORTS.

By T. F. E. Rhead.

DISCUSSION.

Dr. R. H. Griffith (Gas Light and Coke Company) said the author's figures in connection with carburetted water gas were particularly interesting in comparison with similar figures of an ordinary water gas plant, because an inspection of these figures revealed striking differences in the process of oil cracking from that which occurred on the ordinary water gas plant. By allowing for air and flue gases in the carburetted gas, it could be shown that the hydrogen derived from blue water gas was 45·9 p.ct. and 40·7 p.ct. in tests 23 and 26 respectively; and assuming that 0·5 p.ct. of methane was produced from the coke, it was possible to show the composition of the oil gas and the production of hydrogen, methane, and olefines per gallon of oil. Typical figures for a carburetted water gas plant were also given, and it was evident that instead of the usual absorption of hydrogen taking place, some extra hydrogen was actually formed from the oil. This suggested that very different cracking

conditions existed in the vertical retorts, and that small changes in the position of the oil injection tubes might materially affect the results. The yield of therms per gallon of oil could be calculated when the composition of the blue water gas was known, and it was found to be 1·21 and 1·16 in the two cases. The comparative figures were set out as follows:

TABLE III.—(*Rhead*).

—	Test 23.	Test 26.
Air	1·0	1·0
Flue gas	5·8	7·4
Blue gas—		
CO_2	6·9	5·3
CO	32·1	30·1
H_2	45·9	40·7
CH_4	0·5	0·5
Oil gas—		
H_2	1·6	0·5
C_nH_m	2·9	5·7
CH_4	3·3	7·4
C.ft. per gallon of oil—		
H_2	15·7	2·7
C_nH_m	28·4	30·6
CH_4	32·4	39·8
Therms per gallon	1·21	1·16
C.W.G. Plant.		
Gallons per 1000 c.ft.	2·01	..
C.ft. per gallon—		
H_2 absorbed	..	34·8
C_nH_m produced	..	37·3
CH_4 produced	..	59·2
Therms per gallon	1·24	..

Dr. A. PARKER said the comparison of water gas production in a retort with water gas production by the ordinary intermittent process was a matter of some importance. Dr. Griffith had, apparently, carefully analyzed the figures to ascertain the relative volumes of hydrogen in the blue water gas and carburetted gas made by the usual intermittent system and by the process investigated by Mr. Rhead, and had found that the carburetted gas made in the retort contained more hydrogen than the blue gas, whereas carburetted water gas produced by the intermittent system contained less hydrogen. That was a question which the Research Staff of the Institution of Gas Engineers had considered some years ago. Unfortunately the whole of the figures were not published; but on analyzing the figures for gas volumes and compositions the conclusion was reached that in the ordinary process of manufacturing carburetted water gas, hydrogen was absorbed by the oil just as Dr. Griffith had said. In the usual method of gas analysis, hydrogen and methane were determined by passing the residual gas, after the removal of the constituents named prior to hydrogen, over copper oxide at 900° C., and determining the contraction in volume and the carbon dioxide produced. What was usually called methane in an analysis of that type was not entirely methane, but contained also some ethane, so that there would be more free hydrogen than would be calculated from the contraction resulting from combustion over copper oxide at 900° C. The gas analysis should, therefore, be carried out by removing the hydrogen over copper oxide heated to 300° C. and then burning the methane hydrocarbons over copper oxide at 900° C., and finding the volume of CO_2 relative to the volume of gas removed in order to get out the formula of the methane hydrocarbons. The Institution of Gas Engineers Research Committee had done that, and found that there was some loss of free hydrogen, but not as much as would appear from the method of analysis ordinarily adopted. Before any definite conclusions could be drawn as to this particular item of hydrogen production and absorption by the oil, analyses must be carried out more elaborately than was usually the case, otherwise wrong conclusions might easily be drawn. Mr. Rhead recommended the determination of moisture in producer gas and waste gases as a useful indication as to possible loss of steam by leakage through the retort; and he combined these determinations with gas analysis.

THE QUESTION OF LEAKAGE THROUGH RETORT WALLS.

This brought forward a point of considerable interest. All retorts—whether vertical, horizontal, or chamber ovens—were made of porous material, and were all liable at some time or other to develop cracks. So far, no really reliable and simple method of determining the extent of that leakage had been found. In some work on the recovery of waste heat from waste-heat boilers which was carried out for the Institution of Gas Engineers a few years ago, the attempt was made to measure these leakages, and it was found that more steam was raised in the waste-heat boiler than could be accounted for by the waste gases from producer gas alone. More carbon in the form of CO_2 travelled through the waste-heat boiler than could have been produced from the combustion of the fuel supplied to the producers. The radiation losses from the boiler were carefully measured, and the boiler was used as a calorimeter. By calculating the volumes of gases which must have travelled through the boiler and comparing them with the volumes of waste gases of the same composition which could have resulted from the coke supplied to the producers, it was found that there must have been leakage of products of distillation of coal through the retort walls into waste gas flues. Another way of obtaining some idea as to whether leakage was taking place or not, although it would not give an absolute figure, was to determine the composition of the waste gas freed from excess air, and compare the percentage of carbon dioxide with the amount which should be produced on combustion of the producer gas with the theoretical quantity of air. The gas resulting from the combustion of producer gas as calculated by this method usually contained about 20·6 p.ct. of carbon dioxide. Products of distillation of coal yielded a gas containing a smaller percentage of carbon dioxide on combustion, so that a comparison of the two proportions of carbon dioxide indicated whether leakage through the walls of the retorts had occurred. Mr. Rhead had referred to another method of analyzing producer gas for hydrogen and moisture, and comparison of the result with the moisture content of the waste gas. If there had been leakage through the retort wall, then the percentage of moisture in the waste gas would be more than one would calculate from producer gas composition. It was difficult to explain these methods in a few words, but there were three possible methods of getting some idea as to whether leakage was taking place or not.

STEAMING VERTICALS FULL OF COKE.

Mr. L. H. SENSICLE remarked that it occurred to him that there might be special advantages with regard to the possibilities of steaming coke in vertical retorts rather than steaming the charge. When using coals which were strongly coking there seemed a tendency for the coke to hold together in a body and fall down in a mass away from the retort walls at the bottom, and to allow the steam to pass round the outside of the coke. The steam did not seem to pass through the coke in the way that might be expected. In other words, the water gas action took place round the outside, and there was a tendency for steam and water gas to impinge on the walls and possibly loose ash would be carried from the coke on to the refractory material and, in certain cases, cause erosion at the bottom of the retort. That would be avoided to a certain extent if steaming were not necessary in that way as it was possible to steam one or two retorts containing coke only. There was another possibility—that with strongly coking coals the wedge shape of the plastic layer seemed to send the flow of gases along the outside of the plastic layer towards the wall, so that where the plastic layer met the wall towards the top of the retort there appeared to be a concentration of gases there; and it had been noticed that erosion of the retort walls took place at about that point. Again, possibly the erosion was greater when steaming was practised, and the steam carried the CO and perhaps iron-bearing ash along with the gas stream and helped to corrode the bricks. That again would only be likely with very strongly coking coal; and with a coal not strongly coking the plastic layer would allow the gases to go through. By steaming a retort full of graded coke in such cases, the deep localized erosion would be avoided, and the more evenly distributed deterioration of the refractory surface, mentioned by Mr. Rhead as resulting from the process, would not be of serious import when retorts were only taken in turn when due for scurfing.

Mr. JOHN ROBERTS said the last speaker had raised a point which he had intended bringing forward in his own paper to be read on the following day. With certain coals great difficulty had been encountered in steaming. He had been reminded that some coals handled in Birmingham had been found extremely difficult to steam; and it had occurred to him, when the tests at Ramsgate were carried out, that by opening up the coke by blending, as was then done, it ought to be easier to steam the coke than otherwise. For instance, the normal coke made in these retorts was particularly dense and difficult to distinguish from blast-furnace coke. The coke from a blend was very different, and had greater combustibility, so that there appeared to be a relation between combustibility and ease of steaming. He took it that the steam had to come in contact with the carbon; and the less the resistance offered to the steam the greater the facility of steaming, in the same way that the more readily oxygen came in contact with carbon, the greater the ease of combustibility. He just offered the suggestion that these coals which were difficult to steam might be more easily steamed if the coke was opened up by blending.

LIMITATIONS.

Dr. E. W. SMITH said he could give a short account of what had been done, apart from Mr. Rhead's work. Bolton tried this process, and in their new plant they had laid themselves out particularly for running it. Tottenham had tried it and also Margate, and he believed occasionally the experiment had been made in other places; but he considered the process could not be said to be economically sound for satisfactorily working continuous vertical retorts, except under the exceptional conditions which Mr. Rhead had laid down, where particularly difficult coal from the point of view of steaming was in use and low calorific value was required. Then the process paid handsomely; but in no circumstances did it pay even under these conditions if the calorific value of the gas required was 500 B.Th.U. or above. There was a limit to the amount of water gas that could be made per inch of major axis of retort, and that limit was lower than the output of therms obtainable per c.ft. of straight gas made in the ordinary retort. Consequently, from the point of view of thermal output there was no assistance in this special steaming process. As regards the cracking of tar, that was only a matter of technical interest, because with tar at the present price it was much better to use gas oil, which was very little dearer and was much more efficient for gas production, and more likely to be completely free from water; so that even if tar cracking could be employed under smooth working conditions at the present time, it was not an economical thing to do. It was preferable to use gas oil. The process described in the paper was a natural development of a suggestion made by Mr. Tagg to the Fuel Research Board—that there should be cracking of tar in a continuous vertical retort fed with coal. That was tried and reported on by the Fuel Research Board, and some results were obtained. That suggested to others that if instead of putting coal, on which work had to be done, into a retort, graded coke was fed into the retort, then the cracking of tar or oils should be practicable. That was proved to be the case; and all interested in the matter were much indebted to Mr. Rhead, of Birmingham, and Mr. Smith, of Bolton, for having obtained data and information showing the limits of that suggestion.

Mr. MICHAEL BARASH asked if Mr. Rhead had obtained any indica-

tion as to whether the leakage was taking place through the joints in the material or whether it was actually leakage through the brickwork, because that would appear to have some influence on the question of scurfing the retorts. The normal process, before the one described in the paper, was to allow the retorts to carbonize coal for certain definite periods before scurfing; and it seemed to him that that was an advantage from the point of view that the layer of scurf on the surface of the retort prevented leakage and also to some extent protected the brickwork. Without it there was the possibility of constant loss of gas from the retort.

The Author's Reply.

Mr. Rhead, replying to the discussion, said he had not gone very deeply into the question of the composition of carburetted water gas mentioned by Dr. Griffith; but after what had been said he would look into the figures. With regard to Dr. Parker's remarks on the determination of leakage by gas analyses, &c., Dr. Parker's work in Birmingham had been used by the staff there to a considerable extent and found exceedingly valuable. In working out figures from gas analyses where one calculated the composition of the theoretical waste gas from producer gas analyses, there was the difficulty that whereas the leakage of coal gas would cause reduction in the CO_2 percentage in the waste gas, blue gas gave the same composition as the theoretical waste gas from producer gas, and there was no indication that one was losing blue water gas from the bottom of the retort or not. Mr. Sensicle had touched on the possible application of the process, and he himself could do no more than agree with the suggestions made. He could not quite agree with the explanation given by Mr. Sensicle about the erosion of the retorts towards the top. He believed that was very largely due to moisture in the coal and occasional erratic working of the retort which took the raw moist coal farther down at certain times than at others. That was all bound up with the question of the nature of the refractories and the spalling of silica. Chemical action might play some part. but to nothing like the extent that happened lower down the retort. As to the possibility of opening up the coke structure by blending, mentioned by Mr. Roberts, the results met with in vertical retorts from the steaming point of view were largely bound up with the question of the extent to which the coke became fractured. It might be highly reactive; but if it were there in the form of a block, steam would not get to the centre, and for want of that facility the steam would pass up the sides. A lot of work had been done in Birmingham on blending coals with coke dust; and further work of blending coking coals with poor coking coals was in hand. When using coke dust he had found that the effect was to make a very large coke which almost existed as a block in the retort; and the extractor could not readily deal with it—it had to be rodded over. He had given up the idea of blending coals with coke dust as regards continuous vertical retorts. It was interesting to hear Dr. Smith's account of the work at Bolton, Tottenham, and Margate. He gathered that Margate was successfully cracking tar, but he would like to have further enlightenment on that particular point, because he himself considered, from experience, that it was a hopeless process; he would not recommend any engineer to do it in a big retort house. It was not worth the risk and trouble involved in regard to blockages in the retorts and the rest of the system. Mr. Barash had asked whether leakage was through the joints or through the material, and he presumed he meant permeability of the material. He should say that by far the bulk of it was by transportation and not diffusion. The gas passed through leaky joints which occasionally developed. Silica construction had undoubtedly made a very big advance in vertical retort construction, but it had brought certain other difficulties, although these were far outweighed by the advantages. Nevertheless, these troubles had to be recognized, and there was not the slightest doubt that silica must not be allowed to leak. Once a leak was developed in a silica retort it must be patched up as quickly as possible, because if it were allowed to continue there would be coal gas leaking outwards and flue gas leaking inwards, leading to local heating and fusion by chemical action between the ash and the silica material. This would very quickly bring serious trouble and was an important practical point for people working silica vertical retorts or even silica horizontal retorts.

GAS-WORKS REFRACTORIES.

By A. T. Green.

DISCUSSION.

The Chairman said the main point that impressed itself upon his mind in reading the paper was the remark that what was required was a "definition of the actual conditions obtaining in industrial usage." The question was, How could this best be done? He would suggest that it could best be done by all those taking part in the discussion giving their experiences of the use of silica, as regards failures as well as successes. If as a result of the discussion there was a better understanding of exactly what was required, they would have gone a long way; and along with the progress that had been made during the last few years, in the use of silica, they would then be able to tell the makers exactly what they required, and learn themselves, as users, the best types of material and how to employ them.

Co-Operation and Research.

Mr. Frank West agreed with the author that refractories for modern carbonization plants were taxed to the highest degree at the present time. For instance, retorts might be altered in size and shape; but they being asked to give increased duty as time went on, and it was necessary, particularly for manufacturers, to carry out research and go carefully into the manufacture, in order to obtain materials to stand up to these increasing duties. Speaking from the manufacturers' point of view, he could say that they were doing this, and getting better material as time went on. There was little doubt that there must be more research as regards the manufacture; and while users were carrying out individual researches, everybody should do his best to support the British Refractories Research Association, in order that the industry as a whole might get help in the difficulties which were being encountered in practical operation. As regards the use of the cement mortar for jointing, it was essential that the cement mortar used should be made from the materials of which the bricks themselves were made. There were cases in which cement mortar had been used from other materials and had given trouble. It was essential that this whole question should be discussed together by the manufacturers and users, if the best results were to be obtained. He maintained that such a meeting as this assisted materially in this most important matter, as it was composed of users, manufacturers, and scientists. He hoped they would have many more of these combined meetings in the future.

Retort Leakage.

Mr. T. F. E. Rhead said that refractories had received very important consideration in Birmingham, as it had been realized that only by carrying out research, and working with the manufacturers, was it possible to improve these materials. He had been particularly interested in the author's comprehensive summary and explanation of the latest research work in conjunction with practice; and he welcomed such data very heartily. The author's remarks on the absorption of slags by silica had been confirmed on many occasions in the Birmingham laboratories, where it had been found possible to extrude the slag from the silica bricks by putting them under the load test. Curiously enough, however, the silica bricks would be found to have lost very little of their properties in resisting load. He thought he had struck a rather disquieting point some time ago in connection with retort leakage. It seemed possible that the absorption of iron and calcium fluxes, &c., might cause a contraction of the silica material; and he carried out a series of tests under very careful conditions in which pieces of a silica brick were filled up with fluxes such as ferrous sulphide, iron, salt, lime, &c., and heated to 1300° to 1400° C. There was no evidence of any marked contraction or expansion. It was very interesting that, whereas with fireclay materials the matrix pulled all the particles together, and there was a contraction, no such action took place with the silica test pieces. That work had not yet been finished, but so far the results had been reassuring. The remarks that were made in the paper as to increasing conductivity and diffusivity were extremely enlightening. He did not know whether the author had carried out any tests on materials after they had been used.

The Author: Yes.

Mr. Rhead: Does the filling-up of the silica by slag increase the conductivity?

The Author: I have not decided that yet.

Mr. Rhead, continuing, said it would be very interesting to know if the conductivity increased in that way. It was particularly *apropos*, because, as soon as silica or any refractory material was put to work in a setting, it started to change in some way, either physically or chemically, or both, and it was useless to attempt to prognosticate what was going to happen unless the conditions under which the material was working were known. The test of a material in its original state was not necessarily a criterion of how it would behave under practical conditions. The author had mentioned the magnitude of pressures met with in carbonizing settings. Speaking from memory, he himself believed that the superimposed pressure on the bottom brick of a vertical retort setting was about 25 lbs. per sq. in.; but this was not the pressure that caused the trouble. In some cases there were severe compressive phenomena set up due to expansion, and in other cases a tension might be set up, but it was not possible at present to say what were the magnitudes of these pressures and tensions.

Holing of Silica.

Mr. A. Edwards (Gas Light and Coke Company, Beckton) said there was one point in the paper as to the use of silica material which had not been fully explored; and this was the holing which took place in use, especially when temperatures rose above 1330° C. As the author had shown, most fireclays were unstable in the neighbourhood of 1200°. At a little above that point, there was a glassing of the impurities, which drew the silica grains together and eventually led to squatting or flow. With silica, this did not take place, and it could certainly be said that silica bricks, as a building material for retort benches, were immune from anything in the nature of squatting, to which fireclay materials were liable. At Beckton they had standardized silica as the retort building material. It had been found initially that failures were caused by holing and settlement, and these failures were probably due to constructional defects in that allowance was made for an expansion which did not take place. In some cases insufficient allowance was made for expansion in the early days, when silica bricks were not fully converted as they were to-day. Apart from this, however, there had been another type of failure due to the jointing material; and this was causing more trouble to-day than anything else. Many inquiries had been made, and experiments carried out at Beckton, with the object of finding out the real cause of this failure of the cement, and the holing of the retorts. Initially he believed it was a question of sheer refractoriness. The silica material in the retort inevitably expanded in use until it reached its highest temperature; and there it remained. It naturally expanded in all three dimensions. In a horizontal retort it expanded end-ways. Any vertical joints tended to be squeezed, while any longitudinal joints also tended to be extruded. If the cement material failed, as it might do if it were not satisfactory, there was bound to be a contraction. There might be a material shrinkage, but if this happened to the slightest extent, due to the slagging of the less refractory parts, there was inevitable leakage. The gas leakage through the cracks carried iron compounds from the coal ash. Iron in some volatile form—its presence could easily be proved—had an effect upon the jointing material which rapidly became a mass of glass and ultimately ran, leaving a free passage for the gases. Leakage of this sort was a very sore problem not only to those using horizontal retorts, but equally so to those employing the vertical system. As a matter of fact, he thought that it was more important to the vertical retort user than to the horizontal retort user, because the vertical retort was a mass of vertical joints which had no inherent means of closing themselves up in use, where-

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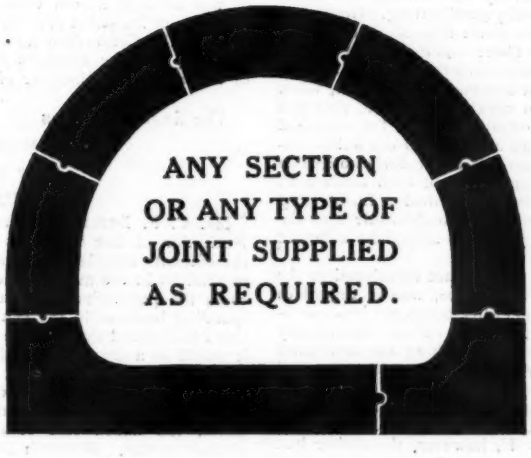

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as the horizontal joint, with its super-imposed weight, would close up. If a leak started, it was practically impossible to prevent it. His experience had been that the cement used for the joints should be of the same refractory material as the silica work itself. Indeed, a fundamental fact was that the cementing material should be more refractory than the bricks. Moreover, this cementing material must be free from any clay substance, because a clay substance contracted, and led to leakage. For these reasons Beckton had used a quartz cement, obtaining plasticity by reducing it to as fine a state as possible by milling and, at the same time, adding a little glue. This material was brought to their notice primarily by one of the silica brick makers.

Question of Working Life of Settings.

Mr. A. H. Andrews (South Metropolitan Gas Company) said that, as one engaged daily in carbonizing work, it seemed to him that they had arrived at the cross-roads. Either they must continue carbonizing in siliceous retorts, or silica material must be adopted. It had been shown in the paper and discussion that a brick made from silica material at certain temperatures would deform, and that in deforming it collapsed as far as carbonization was concerned, because, immediately it deformed, the setting itself was deformed, and therefore ceased to operate as a carbonizing unit. Probably for the last seventy years they had used a material which had shown a remarkable degree of flexibility for the purpose of carbonization—namely, the siliceous retort—and if they were suddenly to depart from this material and their present method of carbonizing, and introduce a material which, according to the curves shown by the author, had an elasticity up to a certain point, after which it deformed, he was afraid those who were responsible for the manufacture of gas would find themselves in a very difficult position. Personally he welcomed heartily the experiments that were being made and the information that was being imparted to the industry, but they must not lose sight of the fact that gas must be produced in large quantities. The industry could not afford to embark readily upon a new venture without assuring itself that the structure of the material of which the settings were composed was of such a character as to ensure stability not for three or four or five hours or even a day, but for a working life equal to present retorts of 2000 to 3000 working days. His own experience with silica retort settings was limited, and he did not propose to impart that experience, because it was not a very happy one. The research work that was being done by the author and other technical workers was welcomed most heartily; and he hoped that it would eventually produce results which would enable carbonizing plants to be more elastic than at present.

Importance of Supervision.

Mr. T. F. E. Rhead entirely agreed with Mr. Edwards' remarks that it was undesirable to put clay in the silica jointing material. There was, however, a great temptation to do it, because silica alone was very difficult to work, and the men did not like it. Another point he wished to make was that the supervision of retort setting was equally important as the quality of the material put in, because it was easily possible to spoil the best material by bad setting, though it was impossible to make bad material good by good setting. He wished to amplify Mr. Edwards' remarks on the point that clay in jointing material led to contraction and leakage. There was the further feature that clay and the various mineral constituents in the coal or flue dust formed a rather fusible slag. Probably it had been noticed that, when taking down horizontal retort settings in which silica shield tiles had been used in division walls made of fireclay material, the slag had collected on the fireclay material and run down on to the silica portion, and absolutely honeycombed it. This was particularly noticeable in silica cross-walls where the jointing material had been made with a certain proportion of fireclay. The fireclay formed a fusible slag with the mineral constituents which penetrated considerably into the silica; and this was another reason why fireclay should be kept out of the jointing material.

Mr. G. J. Greenfield remarked that a point not mentioned in the paper, but which had recently come to his notice, was in regard to the expansion of silica retorts over a period after being put into operation. Had Mr. Green any information as to such retorts continuously expanding for months, or even years, after reaching the maximum working temperature? In one battery of ovens of which he had knowledge, he had not noticed that this was the case. The measurements were not taken in the first place until two months after the plant had been working, but since that time—a matter of years—he had not noticed any further expansion. If, however, the author had any information on the point, it would be extremely interesting.

The Expansion Bogey.

Mr. F. Nicholls (Newcastle-on-Tyne) said there had been considerable reference during the Conference to the expansion of silica, and he was wondering whether it was not being a little overdone, and whether it was not becoming something of a bogey. Five years ago at Newcastle they put in, as an experiment, a certain silica setting. He would not mention the name of the maker, but as he was in the Newcastle district he had better say that it was not Consett silica. That setting was put in without any fuss by a foreman bricklayer whose guiding principle in life was to put a setting in "bottle tight," making no allowance for expansion, and making the joints as small as possible. That setting gave very good results. Some little time afterwards several settings of the same material were put in and the elaborate instructions of the makers of the material as to allowances for expansion were followed. The result, however, was that trouble arose very quickly, and examination of the retort carbon showed signs of spalling along the line of the joints only. The joints were all right with the exception that, though the jointing material did not appear to have failed, there was an opening-up between the tiles. It appeared that the main body of the brickwork had moved into the space which had been allowed for expansion, and exerted a pull on the tiles. It appeared that the carbon had formed in between the tiles, and when scurfing was carried out pieces of silica were torn off the edges of the retort sections. Yet the original setting put in five years ago without allowance for expansion, and working at 1450° C., was still doing well. Unfortunately, owing to a reconstruction scheme, it would have to be pulled out this summer, though it was felt a pity to have to do this. For these reasons he wondered whether the allowance laid down by the Institution of Gas Engineers with regard to expansion was not excessive. He had spoken to some manufacturers at the British Industries Fair, and they were of the opinion that expansion of silica was almost *nil*. As a result of his own experience with four or five varieties, he rather inclined to the same opinion.

The Author's Reply.

Mr. Green, replying to the discussion, thanked Mr. West for emphasizing the need of support for the British Refractories Research Association. It was essential in the especial interests of the carbonizing industries that the fullest knowledge of the properties of refractory materials should be obtained and published. He agreed with Mr. Rhead that the stresses occurring in a refractory wall during usage might be, in certain localized positions, far in excess of those usually anticipated. It was pleasing to find that Mr. Rhead had confirmed his observations concerning the influence of absorbed ferruginous slags on the structural stability of silica products. In reference to the increase in thermal conductivity of fireclay and silica products, he had shown that the conductivity of a semi-silica product which had been in use in a coke oven for eighteen years was appreciably greater than that of the original material. Further, he had proved that the conductivity of both silica and fireclay bricks increased with increasing heat work. These investigations could be found in the recent volumes of the Transactions of the Ceramic Society. With regard to Mr. Edwards' remarks on the holing of retorts, he agreed that the cause of failure was often the cement joints. It did not appear altogether correct to assert that a silica cement should contain no clay, though, of course, the clay content must be a minimum consistent with other desired properties. The condition of the alumina in such fired cements determined the resistance to corrosive and disintegrating action. When the alumina was a constituent part of mullite ($3Al_2O_3 : 2SiO_2$) there was evidence which suggested greater resistance to the aforementioned influences. It would be very interesting to have Mr. Edwards' experience with his cements in two years' time, when proof of their industrial value was realized. Mr. Andrews pleaded caution. However, the accumulated experience of the use of silica and highly siliceous refractories was proving their industrial worth. There were many advantages in the use of these products, but certain inherent disadvantages should be frankly recognized. In reply to Mr. Greenfield, he would state that the term "silica products" was a comprehensive one containing many materials of differing properties. With highly converted silica bricks, he did not anticipate growth over long periods. Often, however, there was a variation from batch to batch, with the result that growth took place over somewhat protracted periods. In general, however, continued growth was not encountered when superior products were used in the carbonizing plant. Mr. Nicholls' statement that the expansion of silica was a "bogey" might be true, but the advantages of this state of affairs were apparent. Did it not result in the inculcation of increased caution in the use of silica? Finally, Mr. Green thanked the Conference for the manner in which the paper had been received, and the speakers for adding materially to the knowledge of the industrial behaviour of refractory materials.

The final paper was

GAS-WORKS EFFLUENTS.

By Dr. A. Parker.

DISCUSSION.

Mr. C. F. Botley (Hastings, Chairman of the Committee of the Institution of Gas Engineers which is dealing with this matter) said the effluents trouble had been accentuated in recent years, due, first, to changes in the method of carbonization, and the fact that in many cases the population had increased considerably without any corresponding increase in the sewerage accommodation. Many gas engineers had solved the problem more or less effectually themselves; and it would be a great help to the Committee and to Dr. Parker if such engineers would state their experiences. The effluent arising from sulphate of ammonia was very trying to the gas engineer to-day if there was trouble in disposing of it. With the present price of sulphate, the added cost of disposing of the effluent became a very serious matter. Research had been suggested to the end that less ammonia should be made, with a consequent reduction in the amount of sulphate and effluent; but perhaps this was getting a little too far ahead. At the same time, any information from those engineers who had been working on the problem would be welcomed by the Committee. It would be unfortunate if a Committee appointed to deal with this serious matter was unable to get the co-operation that was essential if any success was to be obtained as the result of its work.

Effects of Individual Constituents.

Mr. T. R. O'Shaughnessy said that sewage chemists would be relieved to hear that the gas industry was tackling this problem from within the industry. Though the Royal Commission on Sewage Disposal ten or twelve years ago gave considerable attention to the matter, they did not bring out as clearly as possible the nature of the problem. They indicated that in trade effluents generally, the impurities to be dealt with differed substantially from those which had to be dealt with in sewage, and they were of a different order in each trade. Obviously the organic matter present in gas-works effluent in particular was entirely different from that in sewage. For instance, the oxygen absorption figure was not necessarily of the same order of importance with gas-works effluent as with sewage. In investigating various gas liquors, he had found this to be governed very largely by the degree of dilution; and he was glad that Dr. Parker, in his final remarks, emphasized this point. He took it that the methods which were being considered within the industry in

volved considerable capital outlay and possible modification of plants and processes; and therefore it would be necessary to wait a considerable time for these new methods to eventuate and become of any use to the sewage expert in preventing the trouble complained of. He would, however, suggest to Dr. Parker that the method of expressing the impurity coming from a gas-works merely by volume of liquor discharged was highly unsatisfactory, because the strength of the liquor varied greatly in different places. Not only did the organic matter of the gas liquor as a whole differ considerably from that in sewage, but the materials present within the gas liquor itself were of a varying order of importance; and he had not seen that the matter had been tackled from that standpoint. Therefore, the suggestion he wished to make was that possibly the Committee might direct attention to examining the effects of individual materials, like the phenols, sulphocyanide, thiosulphate, &c., and tar bodies, separately with mixtures of sewage, and the corresponding effect on the purification process. If, as the result of this, some better method of expressing more precisely what was involved when a particular gas-works effluent was discharged could be produced, it would be much more helpful and satisfactory. From the foregoing considerations and his own experience, much of the trouble caused by gas liquor in sewage was the intermittent discharge of such waste liquors.

DR. PEXTON'S WORK ON THE SUBJECT.

Dr. S. PEXTON (Gas Light and Coke Company) said that Dr. Parker had given a clear and concise statement of a problem which should engage the attention of all chemists concerned with the carbonization of coal. He had dealt with the prospective methods of eliminating the public nuisance caused by the effluent produced in the manufacture of sulphate of ammonia. So far as could be judged, the major part of the problem, and the one which was most difficult of solution, was the production of an effluent reasonably free from phenol. In this respect some comparative figures for two similar vertical retort installations of the Gas Light and Coke Company, the one carbonizing Yorkshire coal and the other carbonizing Durham coal, might be of interest. The combustion chamber temperatures in the two cases were similar; but it was not to be inferred from this that the temperature inside the retorts in the upper parts were the same, because of the lower throughput of Durham coal.

Carbonization in Vertical Retorts.

—	Yorkshire Coal.	Durham Coal.	Sixty-First Annual Report of Chief Alkali Inspector.
Phenol as C_6H_5OH in the liquor from 100 tons of coal	130 lbs.	70 lbs.	163 lbs.*

* Assuming 50 gallons of liquor per ton of coal.

Temperature conditions inside the carbonizing chamber had such an enormous influence upon the phenol content of the ammoniacal liquor produced that it was difficult to draw any rigid conclusions regarding the effect of the chemical composition of the coal carbonized. It was, however, more than likely that Durham coals with their lower oxygen content produced less phenol than did Yorkshire and Nottinghamshire coals when carbonized under identical conditions. This might be one of the reasons why the liquors produced in London gas-works (where Durham coal was almost exclusively used) were less toxic than was indicated by the figures published and generally accepted for gas-works liquor.

According to the 63rd Report of the Chief Alkali Inspector, the phenol contents of the liquors from Yorkshire coal carbonized in Simon Carves ovens and from Welsh coal carbonized in Otto-Hilgenstock ovens were 240 lbs. and 105 lbs. respectively per 100 tons of coal carbonized.

The early separation of tar and liquor undoubtedly minimized the polyhydric phenol content of the liquor. When carbonizing Durham coal in horizontal retorts at high temperatures, only small quantities of polyhydric phenols were produced; and in one case, when examined in detail, the contact of condenser liquor with the tar which separated prior to the condensers resulted in the transfer of monohydric phenols from the liquor to the tar, and a reduction in the toxicity of the liquor. This aspect of the problem was being followed up more closely; and then it was hoped to give complete details. The phenol content of the mixed liquors from this system was only 15 lbs. per 100 tons of coal carbonized. Attention was drawn to what appeared to be one exception to the statement that "The conditions which favour the formation of thiocyanate also favour the formation of thiosulphate." Gas was passed through a Livesey washed for eight days, during which period no liquor was added or removed from the washer. Two or three per cent. of air was admitted to the gas stream at the inlet of the washer. The thiocyanate content of the liquor increased to almost six times its original value, whereas the thiosulphate content remained practically unchanged. The behaviour of the other impurities during the test could be seen from the table:

—	Commencement of Test.		After 8 Days.	
	Parts per 100.	In Terms of Oxygen Absorbed, Parts per 100,000.	Parts per 100.	In Terms of Oxygen Absorbed, Parts per 100,000.
Monohydric phenols (as C_6H_5OH)	0·227	401	0·220	392
Thiocyanate (as CNS)	0·058	48	0·330	274
Thiosulphate (as S)	0·036	30	0·045	38
Catechol	0·061	76	0·010	13
By difference	..	130	..	223
Total		668		940

In a test on the same washer, when admitting air at the inlet of the oxide purifiers, the thiocyanate content of the liquor increased from 0·067 part per 100 to 0·116 in 7 days, while the thiosulphate content remained unchanged at 0·033 part per 100.

In the scrubber yard of one vertical retort system of the Gas Light and Coke Company, where (*a*) there was the minimum of direct contact of liquor with air, and (*b*) the air for purification was admitted after the scrubber yard, the formation of thiocyanate appeared to have been eliminated.

The following table showed the distribution of phenol and thiocyanate in this system:

—	Phenol as C_6H_5OH in Liquor per 100 Tons of Coal Carbonized, Lbs.	Thiocyanate as CNS in Liquor per 100 Tons of Coal Carbonized, Lbs.
Atmospheric condensers	57·6	1·7
Water cooled condensers	24·5	0·4
Retort house circulating system (tar)	− 8·8	9·2
Scrubber yard	− 5·3	1·2
Oxide purifiers	0·05	19·8
	68	32·3

VIEWS OF DR. MONKHOUSE.

Dr. MONKHOUSE (Hinckley) said that work had been carried out for the Effluents Research Committee at the Hinckley Gas-Works; and it seemed to him that the question could be approached from two points of view—viz., either to find satisfactory methods for removing the noxious constituents from the effluent itself, or to alter the system of condensation of the carbonization process so that the formation of the noxious constituents was minimized or their solution in the liquor prevented. At Hinckley an attempt was being made to minimize the higher tar acids by keeping them in the tar and preventing their solution in the liquor. This was being done by condensing the tar early in the system and keeping it out of contact with the stock liquor by putting it straight into the tar sales tank. Dr. Pexton's remarks were very interesting. In certain circumstances there was a tendency to volatilization of monohydric phenols. With regard to thiocyanate, there was a great variation in the amount found in different ammonia liquors, which was due to the condensing and washing systems in use in various works. In some cases the admission of air seemed a factor; in others the washing of the gas in the Livesey washer or ammonia scrubbers with large volumes of strong ammonia liquor rich in polysulphide was responsible for the removal of the cyanide from the gas as thiocyanate.

EXTRACTION OF PHENOL BY ORGANIC SOLVENTS.

Mr. N. D. LEES, referring to the extraction of phenols by means of an organic solvent such as benzole, as mentioned in the paper, said he saw the Bamag-Meguin plant at Hattingen last month, but noticed a curious air of inactivity about it. He was told that the plant was not working; and the reason seemed to be that given by Dr. Parker. In the original working out of the process, no allowance had been made for the loss of benzole; but in actual practice it had been found that the loss was too high to enable the process to be worked commercially. He had been informed by the Bamag-Meguin people, however, that they had another plant at Oersterfeld, in which this loss was largely overcome by the use of big settling tanks, which enabled the benzole or whatever solvent was used to be separated from the liquor. Intimate mixing and large settling capacity seemed to be the secret of success. It occurred to him that the recovery of phenols in that way was the only economic method of treating effluents, because it gave back something which was of commercial value; and for this reason it appeared probable that it was the coming process. He agreed with Dr. Parker that it was a process which deserved a great deal of attention.

EFFECT OF WASTE LIQUORS ON FISH LIFE.

Mr. NICHOLLS (Newcastle-on-Tyne) said that whereas in the programme of the papers given in the "GAS JOURNAL" Special Number Dr. Parker's paper was supposed to deal with gas-works effluents in general, the heading of the paper was restricted to gas liquor effluents, which question was narrower in scope, and it would be well to bear in mind that Dr. Parker's paper concerned chiefly those gas-works which put spent liquor into the sewers. Many gas-works could not do this—they put their effluent into streams and rivers. So far as he was concerned, there was more trouble with the fishery people with regard to effluents other than spent liquor. Therefore he made the suggestion that the Effluents Committee should consider this aspect of the question, and, further, that each works concerned should tackle the matter, and not throw all the responsibility on the shoulders of the Committee. Of course, there were certain difficulties to be encountered. It was obvious that it was undesirable that oil or evil-smelling liquids should be put into the river; but there were other effluents put into rivers regarding which it was not immediately apparent whether they were harmful to fish or not. A second point was that, whereas the effluent might not affect the fish directly, it might have an effect upon the underwater growth which would, in turn, have a fatal effect upon the fish. It was a question for the biologist and naturalist; and he would refer to it later. Then the question of limits arose. He had heard the suggestion that a certain effluent would not harm fish because it contained only a very weak solution of an alkali. If they looked into the work of the important Committee on Rivers Pollution, it would be found that a concentration of only one part in 20,000 of alkali would be harmful to fish life, and that one part of tar acids in 100,000 would also be harmful. The Royal Commission on Sewage Disposal gave as a limit an oxygen absorption figure of 2 parts in 100,000! If they reckoned this in terms of their old friend naphthalene, this would work out at 3 parts per 100,000, which was a very small allowance. The point he wished to

make was that, though the responsible Department was very reasonable at present, it did not follow that this would always be the case; and the question of whether the industry would be tied down to very small limits in future was not unimportant. It might be that the Department would go further than it did at present, and restrict the industry much more than it did now as regards effluents discharged into streams. He had referred earlier to the question being concerned with the biologist and the naturalist; and he thought that at a conference such as this, some reference should be made to the work of the Standing Committee on River Pollution. Valuable reports had been issued containing information as to the toxic effects of various effluents on fish—questions which did not readily occur to gas engineers and chemists. Further, in the 1925 report was a list of methods worked out by Dr. Jee and his assistants for the examination of effluents; and these should be tried out at every works where there was a competent chemist. Dr. Parker had referred to the question of storing spent liquor. In his own district it had been suggested that the devil liquor should be isolated from the spent liquor, and the former kept out of the river during the months of March, April, and May, when the smolts were coming down the river, and later run off gradually.

LIQUOR STORAGE.

Mr. R. N. S. AVELINE (Coventry), speaking first with regard to the oxygen absorbing power of gas liquor effluents, remarked that it was of interest to note that at Coventry during 1925, when the volumes of liquor produced from the horizontal and vertical retorts were approximately equal—2,438,920 gallons horizontal, and 2,070,100 gallons vertical—the sulphate plant effluent had an oxygen absorption value of about 800 parts per 100,000. At the present time, the major proportion of the production was being carried out in continuous verticals—2·6 gallons of vertical liquor to 1 gallon of horizontal liquor, and the oxygen absorption figure had risen to an average of 980. Individual tests had shown figures as high as 1020 parts per 100,000. Devil liquor at Coventry was about 10 p.ct. of the total effluent, as stated in the paper; but this figure was dependent upon maintaining the economical minimum of steam in the still. The devil liquor separating at the liquor preheaters had been found to have an oxygen absorption figure of 1500, while that condensing at the waste gas coolers had a figure of 1770 parts per 100,000. A reduction of 22 p.ct. in the oyxgen absorption figure of the total effluent was effected by separating the devil liquor from the main still effluent, and evaporating it by means of fine jets delivering a mist into the uptakes from furnaces to chimney stacks in the horizontal retort house. The liquor was vaporized completely, causing no perceptible smell; and no wetting of the flues occurred, provided the jets were kept clean and so delivered a proper spray. Experiments on a small-scale bacterial filter (single filtration) had been carried out, and had yielded excellent results. The filter was made up with active media from a mature bed from a sewage farm that did not have to deal with effluent gas liquor. Mixtures of sewage and spent liquor were then fed to the filter at a rate of 60 gallons per cub. yard per 24 hours, commencing with sewage *plus* 2 p.ct. spent liquor and reaching 8 p.ct. spent liquor within three weeks. With the latter concentration a purification of the mixture of 93·6 p.ct. was obtained, while the bacterial and higher forms of life in the filter were apparently not affected. The procedure then was gradually to reduce the amount of sewage in the mixture, and replace it with treated effluent. The filter was now successfully treating a mixture of one part of spent liquor diluted with 11·5 parts of treated effluent, and showing a purification of 88·8 p.ct. on the feed, or 99 p.ct. calculated on the undiluted liquor. Works-scale plant was now in operation, but at present was only treating a mixture of sewage *plus* 4 p.ct. of spent liquor—or 3500 gallons of spent liquor per day. With this feed, a purification of 90 p.ct. was being effected; but the filters were not yet sufficiently matured to deal with the whole of the spent liquor produced, which amounted to some 50,000 gallons per day. Experimental treatment with flue gases, and also precipitation with alumino-ferric and copper sulphate had been tried; but it seemed that, with an effluent resulting from the distillation of a liquor containing a high proportion of vertical retort liquor, results were not very satisfactory. In one case a maximum reduction of only 6·7 p.ct. in the oxygen absorption value was obtained, with no appreciable alteration in the colour. The Coventry sewage flow was 6 million gallons per day, and the spent liquor was 50,000 gallons per day, or 0·83 p.ct. of the sewage, when the sulphate of ammonia plant was at work; but strong objection was taken even to this small proportion of effluent. As regards the balancing tank, assuming a make of 8 tons per day of sulphate—3900 gallons per ton of 7-oz. liquor—and plant to run for six weeks and be shut down for four weeks, the volume of spent liquor produced per day would be approximately 46,800 gallons. The weekly make would be 327,600 gallons, and in six weeks the quantity would be 1,965,600 gallons. Spread over ten weeks, this would mean 196,560 gallons to be discharged per week. For the four weeks during which the plant would be shut down, storage must be provided for 786,240 gallons of spent liquor; and as this would require a tank 100 ft. long by 50 ft. wide by 25 ft. deep, it was rather expensive in initial outlay.

Mr. CLAYTON (Manchester Oxide Company) said that fifteen or twenty years ago he did a great deal of work on the extraction of the final traces of tar in the gas, working with fans, Livesey washers, &c.; and the conclusion he came to at that time was that, to eliminate the tar in the gas, and so improve the subsequent purification, was too expensive to warrant putting up any proposition to the gas industry. The trouble when taking tar fog out with fans was that a high-speed fan was required; and it would take a 30-H.P. fan to purify 2 million or 3 million c.ft. of gas per day. The cost of the necessary power would run into many hundreds of pounds, and he did not continue the matter. More recently, however, he had determined the sulphocyanide, thiosulphate, and phenols in fifty or sixty samples of various gas-works liquors, and had come to the conclusion that the solution of the problem was on the following lines. In the first place, it was necessary to prevent the tar fog going forward into the condensers, because it conveyed the higher phenols as fog, and not as a vapour, into the condensers. If, therefore, the tar fog was broken down, and taken out of the gas before the water condensers, then the condensed water could not take up higher phenols, as they would not be present. By subsequent shock cooling, an ammonia liquor was obtained which contained a minimum of thiocyanate and thiosulphate, these being formed by long contact of gas and liquor. Tests which he had carried out, working on these lines, showed the quantities formed to be very small. Prevention was better than cure; and if the gas industry were to establish condensation systems on these lines, they would have little trouble from the sewage purification authorities.

ACID WASHERS.

Mr. COOPER (Messrs. W. C. Holmes & Co., Ltd., Huddersfield) said the question of the use of the acid washer was quantitative rather than anything else. If two streams of gas were taken, one of which had a high steam content—say, from a vertical retort with steaming—and the other was gas from a horizontal retort, it would be found that, as the water in the first case condensed, it would in almost every instance draw down the ammonia in greater proportion than in the case of the comparatively dry gas from the horizontal retort setting. In the first case there might be 50 gallons of virgin liquor, and in the second case 20 gallons in the condensed liquor. The first case would allow of the water in the ammonia scrubbers to be cut down to (say) 5 gallons per ton of coal. Taking it at that figure, it would be found that, by saving 5 gallons of water, 10 p.ct. only of the trouble would be saved. The use of the acid washer involved modifications in sulphate plant operation; but he would not say more on this question, because he understood that a paper was shortly to be published on the subject by other investigators, which he would not like to anticipate. The acid washer might assist a solution by reducing total effluents, but would not do a great deal by itself, inasmuch as the proportion saved would not be worth worrying about in the case of a large condensate. With a small condensate, it might be of greater assistance. Similar considerations also applied to direct processes. Dr. Parker had stated that the alternative to indirect ammonia recovery was direct recovery, but he (the speaker) thought it was more accurate to say that there were two other alternatives to direct recovery—namely, indirect and semi-direct—and the choice between the indirect and the semi-direct processes would generally be dictated by considerations such as labour cost on the whole of the bye-product recovery plant, and not by any consideration of effluents.

THE AUTHOR'S REPLY.

Dr. PARKER, replying to the discussion, said he would give a detailed reply in writing; and he asked Dr. Pexton and other contributors to send him any information they might have bearing on the whole question. He especially wished to have some information as to running effluent liquor on to producers, which had not been mentioned in the discussion. He would like to know if there had been any detrimental effect upon the working of the producer. Mr. O'Shaughnessy had referred to the defects of the oxygen absorption test; but that was the best simple test available for comparison. Experiments on individual constituents of effluent gas liquor would come later, but at the present time the work was being directed into such channels as would give a general solution as quickly as possible; and the effects of the individual constituents would be gone into later. Data he would like included in Dr. Pexton's figures were the sulphide contents of the liquors. Dr. Monkhouse, who was in charge of experiments for the Committee, had brought forward some points which indicated the direction in which the work was going; and the programme was actually following the line indicated by Mr. Clayton for improving the composition of the liquor. The experiments were largely based on the work of Dr. Bailey, Chief Inspector of Alkali Works. He thanked Mr. Lees for his remarks with regard to the Hattingen installation, and was glad to know that the position there confirmed the opinion expressed in the paper as to the loss of benzole increasing the cost of phenol recovery. Phenol recovery would be investigated later. Mr. Nicholls had suggested that the troubles at Newcastle were different from those in some other places in that it was desired to run the effluent into a stream. Naturally, all the special cases could not be mentioned in the paper, but there had been inquiries from works similarly situated. The question of the limits of oxygen absorption for effluent to be run into streams was also mentioned by Mr. Nicholls; and although Mr. Nicholls seemed to have some very definite ideas as to the limits which should be imposed, his own experience was that there were no definite limits throughout the country, owing to various requirements. As to the isolation of devil liquor, he thought the best way of getting rid of it was to evaporate it by spraying into a hot chimney. The work being done by Mr. Langford and Mr. Aveline at Coventry was very much appreciated by the Committee. In regard to Mr. Clayton's remarks concerning the removal of tar fog by fan methods, and the power required, the Committee was hoping shortly to investigate an electrostatic plant for the precipitation of tar fog; and as soon as results were available, they would be published. As regards Mr. Cooper's remarks about methods of ammonia recovery, the main point about the direct process from the effluent point of view was that, if the ammonia were removed from the hot gas, there was no ammonia left in the gas leaving the saturator to dissolve hydrogen sulphide and cyanide to produce thiocyanate and thiosulphate; but he realized that the phenols would be dissolved by condensates. As regards acid washers, he presumed Mr. Cooper was speaking of acid washers as used in place of the normal water scrubbers. In the case of some vertical retort systems, no water was supplied to the scrubbers, as there was sufficient water condensing from the gas to wash out the ammonia. In such cases the acid washer could not reduce the volume of effluent.

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